Supporting Information

Cross-Dehydrogenative Coupling Enables Enantioselective Access to CF_3-Substituted All-Carbon Quaternary Stereocenters

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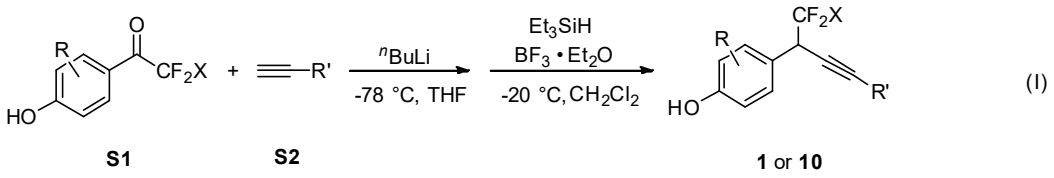
General information

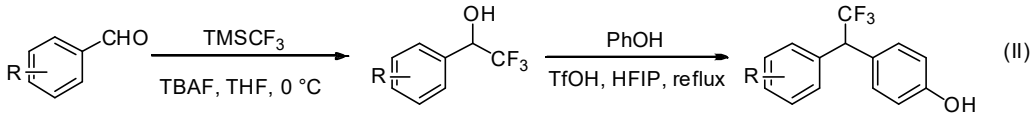
Proton (^{1}H NMR) nuclear magnetic resonance spectra were recorded at 500 or 600 MHz respectively. Carbon (^{13}C NMR) nuclear magnetic resonance spectra were recorded at 126 or 151 MHz respectively. Fluorine (^{19}F NMR) nuclear magnetic resonance spectra were recorded at 471 MHz respectively. The chemical shifts are given in parts per million (ppm) on the delta (δ) scale. The solvent peak was used as a reference value, for ^{1}H NMR: $CDCl_3$ = 7.26 ppm, $(CD_3)_2SO$ = 2.50 ppm, CD_3OD = 3.31 ppm, C_6D_6 = 7.16 ppm; for ^{13}C NMR: $CDCl_3$ = 77.23 ppm, $(CD_3)_2SO$ = 39.51 ppm, CD_3OD = 49.0 ppm, C_6D_6 = 128.06 ppm. Analytical TLC was performed on precoated silica gel GF254 plates. Column chromatography was carried out on silica gel (200–300 mesh). HRMS were carried out on an Orbitrap analyzer. UV spectra were obtained with an Agilent 8453E UV-Visible spectroscopy system. CD spectra were obtained on a Chirascan spectropolarimeter. Optical rotations were measured using a 2.5mL cell with a 10 cm path length on Hanon P850 Automatic Polarimeter and concentrations (c) were reported in g×(100 mL)$^{-1}$. Enantiometric excesses were determined by HPLC using a Daicel Chiralpak and Chiralcel column with hexane/i-PrOH as the eluent on Dionex instrument.

Substrate Preparation



S1 S2 1 or 10 (I)

X= F, Cl, CF_3, C_2F_5



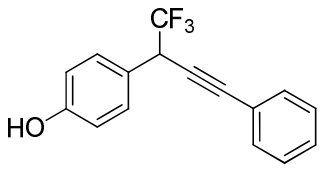
S3 S4 5 (II)

Procedure I for preparation of substrate 1 or 10[1-2]

To a solution of terminal alkyne **S2** (6.3 mmol, 2.1 equiv) in anhydrous THF at -78 °C under N_2 was added ^{n}BuLi (6 mmol, 2.4 mL, 2.5 M in hexane, 2.0 equiv) dropwise. The reaction was stirred at the same temperature for 1 h. Then a solution of the corresponding ketone **S1** (3 mmol, 1.0 equiv) in anhydrous THF (5 mL) was added to the mixture dropwise. The reaction was stirred at -78 °C for 15 min and then it was warmed up to room temperature slowly and stirred overnight. Upon completion, the mixture was quenched dropwise by a saturated aqueous NH_4Cl solution (5 mL). The organic layer was extracted with ethyl acetate (3×15 mL) and the combined organic layers were washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, filtered and removed under vacuum. Then the residue was dissolved in anhydrous CH_2Cl_2 (15 mL) at -20 ℃ and Et_3SiH (12 mmol, 4.0 equiv) and $BF_3{\cdot}Et_2O$ (7.5 mmol, 2.5 equiv) were added to the solution. The reaction was stirred at the same temperature and monitored by TLC until the complete conversion. Then the reaction was quenched by saturated aqueous $NaHCO_3$ solution (10 mL). The organic layer was extracted with CH_2Cl_2 (3×15 mL) and the combined organic layers were washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, filtered and removed under vacuum. The residue was purified by a column chromatography on silica gel using ethyl acetate/petroleum ether as eluent to give the desired product **1** or **10**.

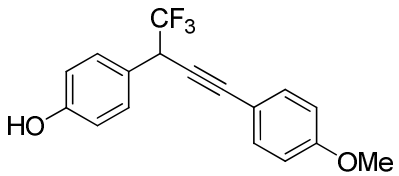
Procedure II for preparation of substrate 5[3-4]

To a solution of aromatic aldehyde **S3** (2.0 mmol, 1.0 equiv) in anhydrous THF at 0 °C under N_2 was added $TMSCF_3$ (2.4 mmol, 1.2 equiv) and TBAF (2.4 mmol, 2.4 mL, 1.0 mol/L in THF, 1.2 equiv) dropwise. Then the reaction was warmed to room temperature and monitored by TLC until the complete conversion. Then the mixture was quenched dropwise by a saturated aqueous NH_4Cl solution (5 mL). The organic layer was extracted with ethyl acetate (3×15 mL) and the combined organic layers were washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, filtered and removed under vacuum. The residue was purified by a column chromatography on silica gel using ethyl acetate/petroleum ether as eluent to give the desired product **S4**. Then the product **S4** was dissolved in HFIP (5 mL) and TfOH (0.05 equiv) and PhOH (3.0 equiv) were added to the solution. The mixture was heated to reflux and monitored by TLC until the complete conversion. Then the reaction was quenched by saturated aqueous $NaHCO_3$ solution (10 mL). The organic layer was extracted with CH_2Cl_2 (3×15 mL) and the combined organic layers were washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, filtered and removed under vacuum. The residue was purified by a column chromatography on silica gel using ethyl acetate/petroleum ether as eluent to give the desired product **5**.



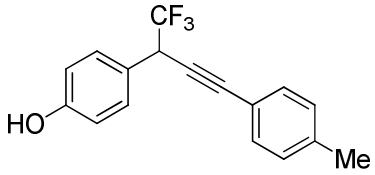
4-(1,1,1-Trifluoro-4-phenylbut-3-yn-2-yl)phenol (1a)

^1H NMR (500 MHz, $CDCl_3$) δ 7.52 (d, *J* = 7.4 Hz, 2H), 7.44 (d, *J* = 8.3 Hz, 2H), 7.39 – 7.32 (m, 3H), 6.88 (d, *J* = 8.4 Hz, 2H), 5.41 (brs, 1H), 4.52 (q, *J* = 8.0 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.2, 132.1, 131.0, 129.0, 128.6, 124.6 (q, *J* = 280.4 Hz), 124.4, 122.4, 115.8, 85.8, 82.1 (q, *J* = 3.2 Hz), 43.5 (q, *J* = 31.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{16}H_{10}F_3O$ $[M - H]^-$ 275.0689, found 275.0679.



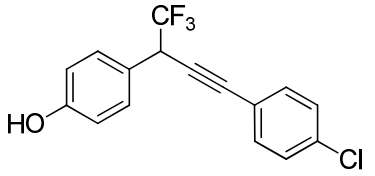
4-(1,1,1-Trifluoro-4-(4-methoxyphenyl)but-3-yn-2-yl)phenol (1b)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.46 – 7.38 (m, 4H), 6.88 – 6.82 (m, 4H), 4.48 (q, *J* = 8.0 Hz, 1H), 3.82 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.1, 156.2, 133.6, 131.0, 124.6 (q, *J* = 280.4 Hz), 124.6, 115.7, 114.5, 114.2, 85.6, 80.6 (q, *J* = 3.3 Hz), 55.5, 43.5 (q, *J* = 31.5 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.9; HRMS (ESI) m/z calculated for $C_{17}H_{12}F_3O_2$ $[M - H]^-$ 305.0795, found 305.0803.



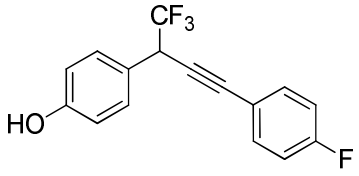
4-(1,1,1-Trifluoro-4-(p-tolyl)but-3-yn-2-yl)phenol (1c)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.46 – 7.36 (m, 4H), 7.15 (d, *J* = 7.9 Hz, 2H), 6.87 (d, *J* = 8.5 Hz, 2H), 5.11 (brs, 1H), 4.50 (q, *J* = 8.0 Hz, 1H), 2.37 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.2, 139.2, 132.0, 131.0, 129.3, 124.6 (q, *J* = 280.4 Hz), 124.5, 119.3, 115.8, 85.9, 81.3 (q, *J* = 3.3 Hz), 43.5 (q, *J* = 31.5 Hz), 21.7; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{17}H_{12}F_3O$ $[M - H]^-$ 289.0846, found 289.0843.



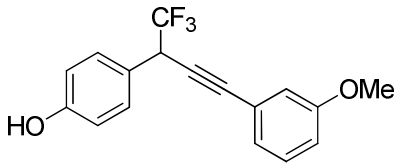
4-(4-(4-Chlorophenyl)-1,1,1-trifluorobut-3-yn-2-yl)phenol (1d)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 – 7.38 (m, 4H), 7.31 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.6 Hz, 2H), 5.33 (brs, 1H), 4.49 (q, *J* = 8.0 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.3, 135.1, 133.3, 130.9, 128.9, 124.5 (q, *J* = 280.4 Hz), 124.1, 120.8, 115.9, 84.6, 83.1 (q, *J* = 3.3 Hz), 43.5 (q, *J* = 31.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{16}H_9ClF_3O$ $[M - H]^-$ 309.0300, found 309.0291.



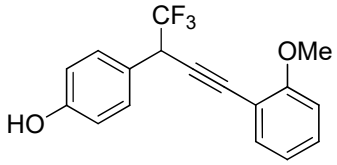
4-(1,1,1-Trifluoro-4-(4-fluorophenyl)but-3-yn-2-yl)phenol (1e)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53 – 7.44 (m, 2H), 7.40 (d, *J* = 8.4 Hz, 2H), 7.09 – 6.98 (m, 2H), 6.87 (d, *J* = 8.4 Hz, 2H), 5.05 (brs, 1H), 4.48 (q, *J* = 8.0 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.0 (d, *J* = 250.1 Hz), 156.3, 134.1 (d, *J* = 8.5 Hz), 130.9, 124.5 (q, *J* = 280.4 Hz), 124.2, 118.4 (d, *J* = 3.5 Hz), 115.9 (d, *J* = 22.1 Hz), 115.8, 84.7, 81.8 (q, *J* = 1.7 Hz), 43.5 (q, *J* = 31.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8, -110.1; HRMS (ESI) m/z calculated for $C_{16}H_9F_4O$ $[M - H]^-$ 293.0595, found 293.0587.



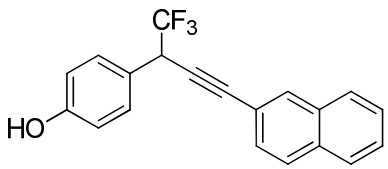
4-(1,1,1-Trifluoro-4-(3-methoxyphenyl)but-3-yn-2-yl)phenol (1f)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.38 (d, *J* = 8.3 Hz, 2H), 7.24 – 7.18 (m, 1H), 7.09 – 7.04 (m, 1H), 7.01 – 6.98 (m, 1H), 6.91 – 6.87 (m, 1H), 6.83 (d, *J* = 8.6 Hz, 2H), 5.26 (brs, 1H), 4.46 (q, *J* = 8.0 Hz, 1H), 3.78 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.4, 156.2, 131.0, 129.7, 124.7, 124.6 (q, *J* = 280.4 Hz), 124.3, 123.4, 116.9, 115.8, 115.6, 85.6, 81.9 (q, *J* = 3.3 Hz), 55.6, 43.5 (q, *J* = 31.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7; HRMS (ESI) m/z calculated for $C_{17}H_{12}F_3O_2$ $[M - H]^-$ 305.0795, found 305.0788.



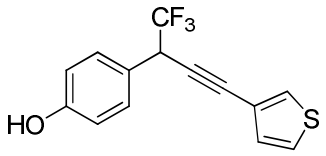
4-(1,1,1-Trifluoro-4-(2-methoxyphenyl)but-3-yn-2-yl)phenol (1g)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.49 – 7.42 (m, 3H), 7.35 – 7.30 (m, 1H), 6.96 – 6.90 (m, 1H), 6.89 (d, *J* = 8.4 Hz, 1H), 6.84 (d, *J* = 8.7 Hz, 2H), 5.08 (brs, 1H), 4.54 (q, *J* = 8.0 Hz, 1H), 3.88 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.7, 156.2, 134.0, 131.1, 130.4, 124.6 (q, *J* = 280.5 Hz), 124.5, 120.7, 115.7, 111.7, 111.1, 86.1 (q, *J* = 3.4 Hz), 82.2, 56.1, 43.7 (q, *J* = 31.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{17}H_{12}F_3O_2$ $[M - H]^-$ 305.0795, found 305.0797.



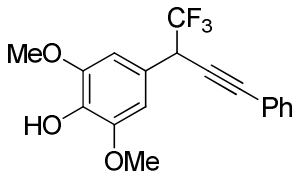
4-(1,1,1-Trifluoro-4-(naphthalen-2-yl)but-3-yn-2-yl)phenol (1h)

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.85 – 7.78 (m, 3H), 7.56 – 7.49 (m, 3H), 7.47 (d, *J* = 8.5 Hz, 2H), 6.89 (d, *J* = 8.7 Hz, 2H), 5.21 (brs, 1H), 4.56 (q, *J* = 8.0 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.3, 133.2, 133.1, 132.2, 131.0, 128.6, 128.3, 128.0, 128.0, 127.1, 126.9, 124.6 (q, *J* = 280.5 Hz), 124.3, 119.6, 115.8, 86.1, 82.3 (q, *J* = 3.3 Hz), 43.6 (q, *J* = 31.5 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7; HRMS (ESI) m/z calculated for $C_{20}H_{12}F_3O$ [M - H]$^-$ 325.0846, found 325.0843.



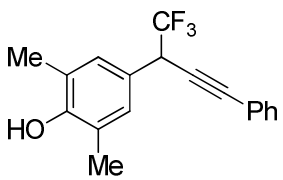
4-(1,1,1-Trifluoro-4-(thiophen-3-yl)but-3-yn-2-yl)phenol (1i)

^{1}H NMR (500 MHz, DMSO-d_6) δ 9.66 (brs, 1H), 7.93 – 7.85 (m, 1H), 7.65 – 7.59 (m, 1H), 7.35 (d, *J* = 8.5 Hz, 2H), 7.24 – 7.19 (m, 1H), 6.82 (d, *J* = 8.6 Hz, 2H), 5.21 (q, *J* = 8.7 Hz, 1H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 157.9, 130.7, 130.4, 129.6, 127.0, 124.8 (q, *J* = 280.0 Hz), 121.7, 120.2, 115.5, 82.2 (q, *J* = 3.1 Hz), 80.0, 41.3 (q, *J* = 30.5 Hz); ^{19}F NMR (471 MHz, Acetone-d_6) δ -71.4; HRMS (ESI) m/z calculated for $C_{14}H_8F_3OS$ [M - H]$^-$ 281.0253, found 281.0248.



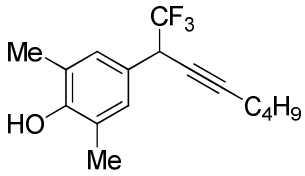
2,6-Dimethoxy-4-(1,1,1-trifluoro-4-phenylbut-3-yn-2-yl)phenol (1j)

^{1}H NMR (500 MHz, CD_3OD) δ 7.49 – 7.44 (m, 2H), 7.39 – 7.32 (m, 3H), 6.84 (s, 2H), 4.85 (brs, 1H), 4.79 (q, *J* = 8.2 Hz, 1H), 3.86 (s, 6H); ^{13}C NMR (126 MHz, CD_3OD) δ 149.2, 137.4, 132.7, 129.9, 129.6, 126.1 (q, *J* = 279.5 Hz),123.8, 123.5, 107.9, 86.3, 83.3 (q, *J* = 3.4 Hz), 56.9, 44.3 (q, *J* = 31.3 Hz); ^{19}F NMR (471 MHz, CD_3OD) δ -72.1; HRMS (ESI) m/z calculated for $C_{18}H_{14}F_3O_3$ [M - H]$^-$ 335.0901, found 335.0908.



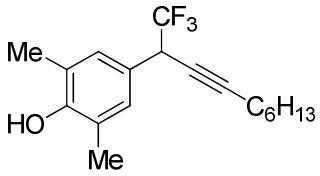
2,6-Dimethyl-4-(1,1,1-trifluoro-4-phenylbut-3-yn-2-yl)phenol (1k)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 – 7.47 (m, 2H), 7.38 – 7.31 (m, 3H), 7.15 (s, 2H), 4.70 (brs, 1H), 4.43 (q, *J* = 8.1 Hz, 1H), 2.28 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.9, 132.1, 129.7, 128.9, 128.5, 126.9 (q, *J* = 280.7 Hz), 123.5, 122.6, 85.5, 82.4 (q, *J* = 3.1 Hz), 43.6 (q, *J* = 31.4 Hz), 16.1; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7; HRMS (ESI) m/z calculated for $C_{18}H_{14}F_3O$ $[M - H]^-$ 303.1002, found 303.0998.



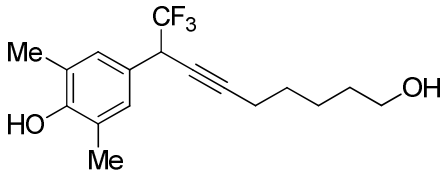
2,6-Dimethyl-4-(1,1,1-trifluorooct-3-yn-2-yl)phenol (1l)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.08 (s, 2H), 4.69 (brs, 1H), 4.18 (qt, *J* = 8.2, 2.2 Hz, 1H), 2.30 – 2.24 (m, 8H), 1.59 – 1.52 (m, 2H), 1.50 – 1.42 (m, 2H), 0.94 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.7, 129.6, 124.9 (q, *J* = 280.1 Hz), 124.2, 123.3, 86.2, 73.2 (q, *J* = 3.2 Hz), 43.0 (q, *J* = 31.1 Hz), 30.8, 22.1, 18.6, 16.1, 13.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.1;HRMS (ESI) m/z calculated for $C_{16}H_{18}F_3O$ $[M - H]^-$ 283.1315, found 283.1321.



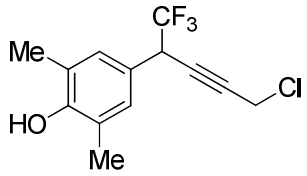
2,6-Dimethyl-4-(1,1,1-trifluorodec-3-yn-2-yl)phenol (1m)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.07 (s, 2H), 4.68 (brs, 1H), 4.17 (qt, *J* = 8.2, 2.2 Hz, 1H), 2.27 – 2.24 (m, 8H), 1.58 – 1.51 (m, 2H), 1.45 – 1.38 (m, 2H), 1.33 – 1.26 (m, 4H), 0.89 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.7, 129.6, 124.9 (q, *J* = 280.1 Hz), 124.2, 123.3, 86.3, 73.2 (q, *J* = 3.5 Hz), 43.0 (q, *J* = 30.9 Hz), 31.5, 28.7, 28.7, 22.8, 18.9, 16.1, 14.2; ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.2; HRMS (ESI) m/z calculated for $C_{18}H_{22}F_3O$ $[M - H]^-$ 311.1628, found 311.1620.



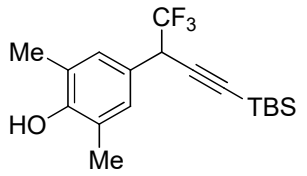
2,6-Dimethyl-4-(1,1,1-trifluoro-9-hydroxynon-3-yn-2-yl)phenol (1n)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.06 (s, 2H), 4.20 – 4.12 (m, 1H), 3.66 (t, *J* = 6.5 Hz, 2H), 2.30 – 2.23 (m, 8H), 1.63 – 1.55 (m, 4H), 1.52 – 1.47 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.6, 129.4, 124.7 (q, *J* = 280.2 Hz), 123.8, 123.3, 85.7, 73.3 (q, *J* = 3.8 Hz), 62.9, 42.7 (q, *J* = 31.2 Hz), 32.2, 28.2, 24.9, 18.7, 16.0; ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.1; HRMS (ESI) m/z calculated for $C_{17}H_{20}F_3O_2$ $[M - H]^-$ 313.1421, found 313.1423.



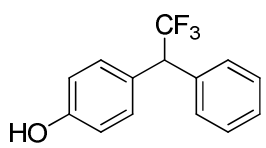
4-(5-Chloro-1,1,1-trifluoropent-3-yn-2-yl)-2,6-dimethylphenol (1o)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.04 (s, 2H), 4.28 – 4.23 (m, 1H), 4.21 (d, *J* = 2.1 Hz, 2H), 2.26 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.0, 129.6, 124.4 (q, *J* = 280.4 Hz), 123.6, 122.7, 80.3, 79.8 (q, *J* = 3.0 Hz), 43.0 (q, *J* = 31.6 Hz), 30.4, 16.1; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.4; HRMS (ESI) m/z calculated for $C_{13}H_{11}ClF_3O$ $[M - H]^-$ 275.0456, found 275.0449.



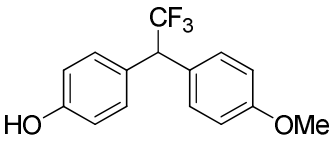
4-(4-(Tert-butyldimethylsilyl)-1,1,1-trifluorobut-3-yn-2-yl)-2,6-dimethylphenol (1p)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.09 (s, 2H), 4.70 (brs, 1H), 4.23 (q, *J* = 8.1 Hz, 1H), 2.26 (s, 6H), 0.98 (s, 9H), 0.15 (s, 3H), 0.15 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.8, 129.8, 124.5 (q, *J* = 280.4 Hz),123.4, 123.3, 99.0 (q, *J* = 3.1 Hz),89.5, 43.8 (q, *J* = 31.2 Hz), 26.2, 16.9, 16.1, -4.6; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.9; HRMS (ESI) m/z calculated for $C_{18}H_{24}F_3OSi$ $[M - H]^-$341.1554, found 341.1568.



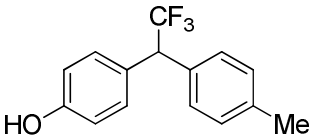
4-(2,2,2-Trifluoro-1-phenylethyl)phenol (5a)

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.41 – 7.28 (m, 5H), 7.24 (d, *J* = 8.3 Hz, 2H), 6.81 (d, *J* = 8.6 Hz, 2H), 4.63 (q, *J* = 10.0 Hz, 1H); ^{13}C NMR (151 MHz, $CDCl_3$) δ 155.3, 135.8 (q, *J* = 1.0 Hz), 130.7, 129.2, 128.9, 128.0, 128.0 (q, *J* = 1.4 Hz), 126.4 (q, *J* = 280.4 Hz, 2H), 115.8, 54.9 (q, *J* = 27.5 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -66.1; HRMS (ESI) m/z calculated for $C_{14}H_{10}F_3O$ [M - H]$^-$ 251.0689, found 251.0694.



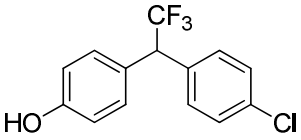
4-(2,2,2-Trifluoro-1-(4-methoxyphenyl)ethyl)phenol (5b)

^{1}H NMR (500 MHz, CD_3OD) δ 7.27 (d, *J* = 8.7 Hz, 2H), 7.19 (d, *J* = 8.5 Hz, 2H), 6.85 (d, *J* = 8.8 Hz, 2H), 6.76 (d, *J* = 8.7 Hz, 2H), 4.67 (q, *J* = 10.4 Hz, 1H), 3.72 (s, 3H); ^{13}C NMR (126 MHz, CD_3OD) δ 160.6, 158.1, 131.2, 131.2, 129.5, 128.1, 128.1 (q, *J* = 279.5 Hz), 116.3, 114.9, 55.6, 54.8 (q, *J* = 27.4 Hz); ^{19}F NMR (471 MHz, CD_3OD) δ -67.8; HRMS (ESI) m/z calculated for $C_{15}H_{12}F_3O_2$ [M - H]$^-$ 281.0795, found 281.0803.



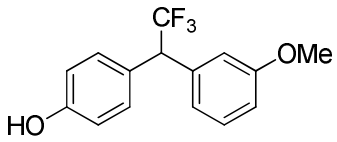
4-(2,2,2-Trifluoro-1-(p-tolyl)ethyl)phenol (5c)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.30 – 7.24 (m, 4H), 7.19 (d, *J* = 7.9 Hz, 2H), 6.82 (d, *J* = 8.6 Hz, 2H),5.19 (brs, 1H),4.61 (q, *J* = 10.0 Hz, 1H), 2.36 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.2, 137.8, 132.9, 130.6, 129.6, 129.0, 128.2 (q, *J* = 1.5 Hz), 126.5 (q, *J* = 280.4 Hz), 115.7, 54.6 (q, *J* = 27.5 Hz), 21.2; ^{19}F NMR (471 MHz, $CDCl_3$) δ -66.2; HRMS (ESI) m/z calculated for $C_{15}H_{12}F_3O$ [M - H]$^-$ 265.0846, found 265.0839.



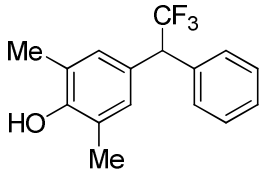
4-(1-(4-Chlorophenyl)-2,2,2-trifluoroethyl)phenol (5d)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.27 (m, 4H), 7.20 (d, *J* = 8.6 Hz, 2H), 6.82 (d, *J* = 8.7 Hz, 2H), 5.08 (brs, 1H), 4.60 (q, *J* = 9.8 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.6, 134.4, 134.1, 130.6, 130.6, 129.1, 127.4, 126.2 (q, *J* = 280.4 Hz), 115.9, 54.3 (q, *J* = 27.8 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -66.3; HRMS (ESI) m/z calculated for $C_{14}H_9ClF_3O$ $[M - H]^-$ 285.0300, found 285.0306.



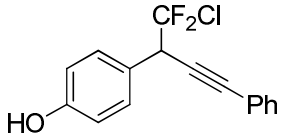
4-(2,2,2-Trifluoro-1-(3-methoxyphenyl)ethyl)phenol (5e)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 – 7.23 (m, 1H), 7.21 (d, *J* = 8.6 Hz, 2H), 6.96 (d, *J* = 7.7 Hz, 1H), 6.91 (s, 1H), 6.86 – 6.82 (m, 1H), 6.76 (d, *J* = 8.7 Hz, 2H), 5.53 (brs, 1H), 4.57 (q, *J* = 9.9 Hz, 1H), 3.77 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.8, 155.4, 137.3, 130.6, 129.9, 127.8, 126.4 (q, *J* = 280.5 Hz), 121.7, 115.8, 115.5, 113.1, 55.5, 54.9 (q, *J* = 27.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -66.0; HRMS (ESI) m/z calculated for $C_{15}H_{12}F_3O_2$ $[M - H]^-$ 281.0795, found 281.0799.



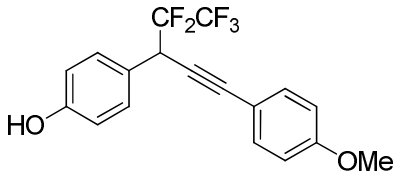
2,6-Dimethyl-4-(2,2,2-trifluoro-1-phenylethyl)phenol (5f)

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.42 – 7.34 (m, 4H), 7.34 – 7.30 (m, 1H), 7.00 (s, 2H), 4.65 (brs, 1H), 4.57 (q, *J* = 10.1 Hz, 1H), 2.24 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.1, 136.1 (q, *J* = 1.2 Hz), 129.5, 129.2, 128.9, 127.9, 127.2 (q, *J* = 1.3 Hz), 126.6 (q, *J* = 280.5 Hz), 123.5, 55.1 (q, *J* = 27.4 Hz), 16.2; ^{19}F NMR (471 MHz, $CDCl_3$) δ -66.0; HRMS (ESI) m/z calculated for $C_{16}H_{14}F_3O$ $[M - H]^-$ 279.1002, found 279.0993.



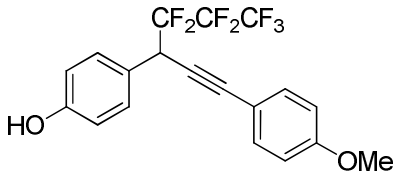
4-(1-Chloro-1,1-difluoro-4-phenylbut-3-yn-2-yl)phenol (10a)

^{1}H NMR (500 MHz, CD_3OD) δ 7.51 – 7.42 (m, 2H), 7.38 (d, 2H), 7.35 – 7.26 (m, 3H), 6.85 – 6.81 (m, 2H), 4.84 – 4.73 (m, 1H); ^{13}C NMR (126 MHz, CD_3OD) δ 159.1, 132.6, 132.1, 130.2 (t, *J* = 295.0 Hz), 129.8, 129.5, 124.8, 123.6, 116.2, 86.7, 84.4 (t, *J* = 4.5 Hz), 50.4 (t, *J* = 27.2 Hz); ^{19}F NMR (471 MHz, CD_3OD) δ -51.64 – -54.25 (m, 2F); HRMS (ESI) m/z calculated for $C_{16}H_{10}ClF_2O$ $[M - H]^-$ 291.0394, found 291.0399.



4-(4,4,5,5,5-Pentafluoro-1-(4-methoxyphenyl)pent-1-yn-3-yl)phenol (10b)

^{1}H NMR (500 MHz, CD_3OD) δ 7.38 – 7.31 (m, 4H), 6.89 – 6.86 (m, 2H), 6.82 (d, *J* = 8.6 Hz, 2H), 4.75 – 4.65 (m, 1H), 3.77 (s, 3H); ^{13}C NMR (126 MHz, CD_3OD) δ 161.5, 159.2, 134.1, 132.0, 123.5, 125.4 – 116.1 (m), 116.4, 115.5, 115.1, 86.8, 81.3 (dd, *J* = 9.3, 2.5 Hz),55.8, 41.6 (dd, *J* = 26.6, 22.4 Hz); ^{19}F NMR (471 MHz, CD_3OD) δ -82.3 – -82.5 (m, 3F), -115.7 – -122.6 (m, 2F); HRMS (ESI) m/z calculated for $C_{18}H_{12}F_5O_2$ $[M - H]^-$ 355.0763, found 355.0755.



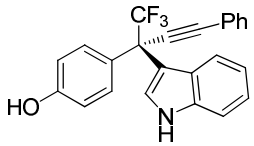
4-(4,4,5,5,6,6,6-Heptafluoro-1-(4-methoxyphenyl)hex-1-yn-3-yl)phenol (10c)

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 – 7.39 (m, 4H), 6.89 – 6.85 (m, 4H), 5.48 (brs, 1H), 4.61 – 4.52 (m, 1H), 3.82 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.1, 156.3, 133.5, 131.6, 123.8, 115.7, 114.6, 121.99 – 106.96 (m), 114.2, 86.3, 80.3 (d, *J* = 9.8 Hz), 55.5, 41.1 (dd, *J* = 27.7, 22.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -80.6 – -80.7 (m, 3F), -111.5 – -112.3 (m, 1F), -116.5 – -117.3 (m,1F), -122.6 – -125.3 (m, 2F); HRMS (ESI) m/z calculated for $C_{19}H_{12}F_7O_2$ $[M - H]^-$ 405.0731, found 405.0744.

General procedure

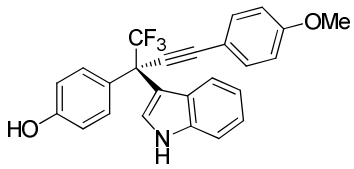
General procedure for asymmetric CDC of racemic *p*-hydroxybenzyl CF_3 moieties with heteroarenes

A mixture of **1** or **5** (0.1 mmol, 1.0 equiv), activated MnO_2 (0.3 mmol, 3.0 equiv), and DDQ (0.025 mmol, 0.25 equiv) in anhydrous CH_2Cl_2 (1.0 mL) was stirred at 60 °C in a sealed tube and monitored by TLC. Upon starting material consumption, the mixture was cooled to -78 °C directly and stirred at the same temperature for 15 min. (Note: the paraquinomethide could be stable in this system.) Then 3Å molecular sieves (20 mg), K_2CO_3 (0.2 mmol, 2.0 equiv), **2a** (0.3 mmol, 3.0 equiv) and catalyst **3c** (0.005 mmol, 0.05 equiv) were added in sequence quickly. (Attention: the order of addition is important.) Then the mixture was stirred at the same temperature and monitored by TLC. Upon completion, the reaction was warm to room temperature and a solution of saturated aqueous NaCl solution (1 ml) was added to the mixture. Then the mixture was extracted with EtOAc, and the combined organic layer was dried over $MgSO_4$, filtered and evaporated under vacuum. The residue was purified by a flash column chromatography to give the desired product.



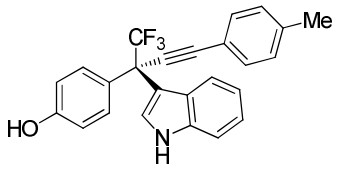
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (4a)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 86% (33.7 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.17 (brs, 1H), 7.53 (d, *J* = 8.6 Hz, 2H), 7.50 – 7.45 (m, 2H), 7.42 – 7.27 (m, 6H), 7.20 – 7.15 (m, 1H), 7.01 – 6.96 (m, 1H), 6.77 (d, *J* = 8.8 Hz, 2H); ^{13}C NMR (151 MHz, $CDCl_3$) δ 155.7, 136.6, 132.1, 130.7, 129.1, 128.8, 128.5, 125.8 (q, *J* = 284.2 Hz), 125.7, 123.0 (q, *J* = 2.6 Hz), 122.6, 122.6, 121.3, 120.1, 115.2, 112.6, 111.4, 86.5, 86.2 (q, *J* = 1.5 Hz), 51.2 (q, *J* = 29.3 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.5; HRMS (ESI) m/z calculated for $C_{24}H_{15}F_3NO$ $[M - H]^-$ 390.1111, found 390.1116; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 227 nm), retention time: t_{minor} = 13.790 min, t_{major} = 16.100 min, ee = 92.6%; $[\alpha]_D^{30}$ = -96.5 (c = 0.98, $CHCl_3$).



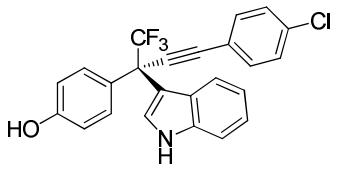
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-(4-methoxyphenyl)but-3-yn-2-yl)phenol (4b)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 89% (37.5 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.17 (brs, 1H), 7.53 (d, *J* = 8.6 Hz, 2H), 7.43 – 7.31 (m, 5H), 7.18 – 7.15 (m, 1H), 6.99 – 6.95 (m, 1H), 6.82 (d, *J* = 8.9 Hz, 2H), 6.76 (d, *J* = 8.8 Hz, 2H), 3.80 (s, 3H); ^{13}C NMR (151 MHz, $CDCl_3$) δ 160.0, 155.7, 136.6, 133.5, 130.7, 129.3, 125.8 (q, *J* = 284.0 Hz), 125.7, 123.0 (q, *J* = 2.4 Hz), 122.6, 121.3, 120.0, 115.1, 114.8, 114.1, 112.8, 111.3, 86.4, 84.8 (q, *J* = 1.5 Hz), 55.5, 51.2 (q, *J* = 29.1 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO_2$ $[M - H]^-$ 420.1217, found 420.1211; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 266 nm), retention time: t_{minor} = 12.620 min, t_{major} = 15.593 min, ee = 95.1%; $[\alpha]_D^{30}$ = -119.3 (c = 1.00, $CHCl_3$).



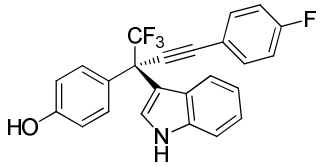
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-(p-tolyl)but-3-yn-2-yl)phenol (4c)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 85% (34.4 mg). ^{1}H NMR (500 MHz, CD_3OD) δ 7.42 (d, *J* = 8.7 Hz, 2H), 7.39 – 7.34 (m, 2H), 7.34 – 7.28 (m, 2H), 7.23 – 7.19 (m, 1H), 7.17 – 7.12 (m, 2H), 7.10 – 7.04 (m, 1H), 6.88 – 6.82 (m, 1H), 6.73 (d, *J* = 8.8 Hz, 2H), 2.32 (s, 3H); ^{13}C NMR (126 MHz, CD_3OD) δ 158.6, 140.1, 138.3, 132.6, 131.3, 130.2, 129.0, 127.2 (q, *J* = 282.9 Hz), 126.8, 124.2 (q, *J* = 2.5 Hz), 122.7, 121.7, 120.8, 119.9, 115.7, 112.7, 112.4, 87.2, 87.0 (q, *J* = 1.7 Hz), 52.4 (q, *J* = 29.1 Hz), 21.4; ^{19}F NMR (471 MHz, CD_3OD) δ -71.9; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO$ $[M - H]^-$ 404.1268, found 404.1280; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 258 nm), retention time: t_{minor} = 14.363 min, t_{major} = 17.240 min, ee = 89.9%; $[\alpha]_D^{30}$ = -95.3 (c = 1.00, $CHCl_3$).



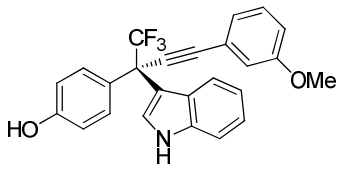
(*S*)-4-(4-(4-Chlorophenyl)-1,1,1-trifluoro-2-(1*H*-indol-3-yl)but-3-yn-2-yl)phenol (4d)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 80% (34.0 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.20 (brs, 1H), 7.50 (d, *J* = 8.6 Hz, 2H), 7.42 – 7.36 (m, 4H), 7.32 – 7.26 (m, 3H), 7.21 – 7.15 (m, 1H), 7.01 – 6.95 (m, 1H), 6.77 (d, *J* = 8.8 Hz, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.6, 136.4, 134.7, 133.1, 130.4, 128.6, 128.6, 125.5 (q, *J* = 284.2 Hz), 125.5, 122.9 (q, *J* = 2.6 H), 122.5, 121.0, 120.9, 119.9, 115.0, 112.2, 111.2, 87.1 (q, *J* = 1.5 Hz), 85.18, 51.1 (q, *J* = 29.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.6; HRMS (ESI) m/z calculated for $C_{24}H_{14}ClF_3NO$ $[M - H]^-$ 424.0721, found 424.0715; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 253 nm), retention time: t_{minor} = 12.620 min, t_{major} = 15.593 min, ee = 91.2%; $[\alpha]_D^{30}$ = -125.8 (c = 1.02, $CHCl_3$).



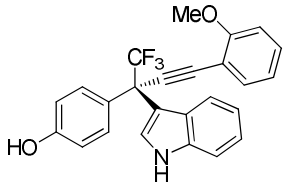
(*S*)-4-(1,1,1-Trifluoro-4-(4-fluorophenyl)-2-(1*H*-indol-3-yl)but-3-yn-2-yl)phenol (4e)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 76% (31.0 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 (brs, 1H), 7.51 (d, *J* = 8.6 Hz, 2H), 7.47 – 7.42 (m, 2H), 7.42 – 7.37 (m, 2H), 7.33 – 7.29 (m, 1H), 7.19 – 7.15 (m, 1H), 7.03 – 6.93 (m, 3H), 6.77 (d, *J* = 8.8 Hz, 2H), 4.83 (brs, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 162.9 (d, *J* = 249.8 Hz), 155.8, 136.6, 134.0 (d, *J* = 8.4 Hz), 130.7, 129.0, 125.7 (q, *J* = 284.0 Hz), 125.7, 123.0 (q, *J* = 2.6 Hz), 122.7, 121.2, 120.1, 118.7 (d, *J* = 3.5 Hz), 115.8 (d, *J* = 22.1 Hz), 115.2, 112.5, 111.4, 86.0 (q, *J* = 1.6 Hz), 85.5, 51.2 (q, *J* = 29.1 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7, -110.4; HRMS (ESI) m/z calculated for $C_{24}H_{14}F_4NO$ $[M - H]^-$ 408.1017, found 408.1008; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 215 nm), retention time: t_{minor} = 13.690 min, t_{major} = 16.470 min, ee = 95.8%; $[\alpha]_D^{30}$ = -105.5 (c = 0.98, $CHCl_3$).



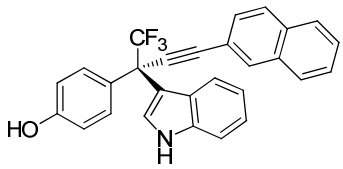
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-(3-methoxyphenyl)but-3-yn-2-yl)phenol (4f)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 85% (35.6 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (brs, 1H), 7.53 (d, *J* = 8.6 Hz, 2H), 7.40 – 7.33 (m, 3H), 7.23 – 7.15 (m, 2H), 7.10 – 7.06 (m, 1H), 7.01 – 6.96 (m, 2H), 6.90 – 6.86 (m, 1H), 6.76 (d, *J* = 8.8 Hz, 2H), 4.92 (brs, 1H), 3.77 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.5, 155.7, 136.6, 130.7, 129.6, 129.0, 125.8 (q, *J* = 284.3 Hz), 125.7, 124.7, 123.6, 123.1 (q, *J* = 2.7 Hz), 122.7, 121.3, 120.1, 116.9, 115.5, 115.2, 112.6, 111.4, 86.4, 86.1 (q, *J* = 1.7 Hz), 55.5, 51.3 (q, *J* = 29.3 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.6; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO_2$ $[M - H]^-$ 420.1217, found 420.1222; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 225nm), retention time: t_{minor} = 16.943 min, t_{major} = 19.467 min, ee = 92.3%; $[\alpha]_D^{30}$ = -113.6 (c = 0.99, $CHCl_3$).



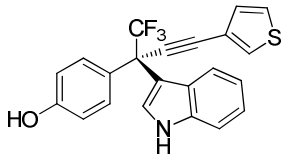
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-(2-methoxyphenyl)but-3-yn-2-yl)phenol (4g)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 81% (34.0 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.16 (brs, 1H), 7.60 (d, *J* = 8.6 Hz, 2H), 7.45 – 7.38 (m, 3H), 7.36 – 7.33 (m, 1H), 7.30 – 7.26 (m, 1H), 7.17 – 7.13 (m, 1H), 6.98 – 6.95 (m, 1H), 6.89 – 6.85 (m, 2H), 6.76 (d, *J* = 8.8 Hz, 2H), 3.85 (s, 3H); ^{13}C NMR (151 MHz, $CDCl_3$) δ 160.9, 155.6, 136.6, 133.7, 130.8, 130.2, 129.3, 125.8 (q, *J* = 284.3 Hz), 125.7, 123.1 (q, *J* = 2.4 Hz), 122.5, 121.7, 120.5, 119.9, 115.1, 112.7, 112.1, 111.2, 111.0, 90.1 (q, *J* = 1.4 Hz), 83.1, 56.0, 51.4 (q, *J* = 29.2 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.5; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO_2$ $[M - H]^-$ 420.1217, found 420.1219; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 291 nm), retention time: t_{minor} = 23.080 min, t_{major} = 26.093 min, ee = 96.2%; $[\alpha]_D^{30}$ = -79.4 (c = 0.99, $CHCl_3$).



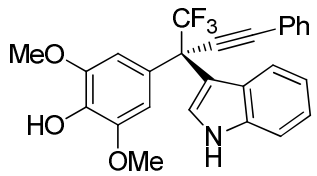
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-(naphthalen-2-yl)but-3-yn-2-yl)phenol (4h)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 67% (29.5 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (brs, 1H), 8.00 (s, 1H), 7.81 – 7.74 (m, 3H), 7.58 (d, *J* = 8.6 Hz, 2H), 7.53 – 7.46 (m, 3H), 7.44 – 7.35 (m, 3H), 7.22 – 7.16 (m, 1H), 7.04 – 6.99 (m, 1H), 6.78 (d, *J* = 8.8 Hz, 2H), 4.99 (brs, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.8, 136.6, 133.2, 133.1, 132.1, 130.7, 129.1, 128.7, 128.1, 128.0, 128.0, 127.0, 126.8, 125.8 (q, *J* = 284.3 Hz), 125.7, 123.1 (q, *J* = 2.2 Hz), 122.7, 121.3, 120.1, 119.9, 115.2, 112.6, 111.4, 86.9, 86.5 (q, *J* = 1.6 Hz), 51.3 (q, *J* = 29.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.5; HRMS (ESI) m/z calculated for $C_{28}H_{17}F_3NO$ $[M - H]^-$ 440.1268, found 440.1257; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 290 nm), retention time: t_{minor} =10.457 min, t_{major} = 12.797min, ee = 92.1%; $[\alpha]_D^{30}$ = -63.7 (c = 1.03, $CHCl_3$).



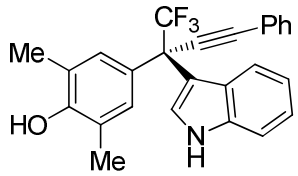
(*S*)-4-(1,1,1-Trifluoro-2-(1*H*-indol-3-yl)-4-(thiophen-3-yl)but-3-yn-2-yl)phenol (4i)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 83% (32.8 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (brs, 1H), 7.51 (d, *J* = 8.6 Hz, 2H), 7.49 – 7.45 (m, 1H), 7.40 – 7.35 (m, 2H), 7.34 – 7.30 (m, 1H), 7.26 – 7.23 (m, 1H), 7.19 – 7.15 (m, 1H), 7.14 – 7.11 (m, 1H), 7.00 – 6.95 (m, 1H), 6.76 (d, *J* = 8.8 Hz, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.8, 136.6, 130.7, 130.2, 129.6, 129.0, 125.7 (q, *J* = 284.2 Hz), 125.7, 125.5, 123.1 (q, *J* = 2.7 Hz), 122.6, 121.6, 121.3, 120.1, 115.2, 112.5, 111.4, 85.8 (q, *J* = 1.6 Hz), 81.7, 51.3 (q, *J* = 29.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.6; HRMS (ESI) m/z calculated for $C_{22}H_{13}F_3NOS$ $[M - H]^-$ 396.0675, found 396.0683; HPLC: the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 215 nm), retention time: t_{minor} =20.300 min, t_{major} = 22.877min, ee = 96.2%; $[\alpha]_D^{30}$ = -93.8 (c = 0.98, $CHCl_3$).



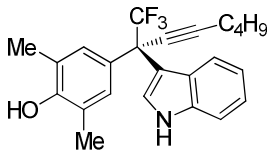
(*S*)-2,6-Dimethoxy-4-(1,1,1-trifluoro-2-(1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (4j)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 63% (28.5 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (brs, 1H), 7.50 – 7.45 (m, 2H), 7.43 – 7.35 (m, 3H), 7.35 – 7.27 (m, 3H), 7.19 – 7.15 (m, 1H), 7.03 – 6.98 (m, 1H), 6.96 (s, 2H), 5.59 (brs, 1H), 3.78 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.7, 136.6, 135.1, 132.0, 128.9, 128.5, 127.8, 125.8 (q, J = 284.4 Hz), 125.8, 123.2 (q, J = 2.5 Hz), 122.6, 122.6, 121.3, 120.1, 112.4, 111.4, 106.7, 86.7, 86.2, 56.6, 51.9 (q, J = 29.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.2; HRMS (ESI) m/z calculated for $C_{26}H_{19}F_3NO_3$ [M - H]$^-$ 450.1323, found 450.1327; HPLC: the the ee value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 220 nm), retention time: t_{minor} = 7.267 min, t_{minor} = 10.190 min, ee = 83.0%; $[\alpha]_D^{30}$ = -9.6 (c = 1.04, $CHCl_3$).



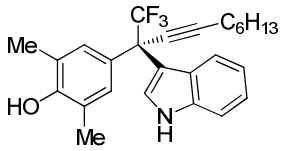
(*S*)-2,6-Dimethyl-4-(1,1,1-trifluoro-2-(1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (4k)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 76% (32.0 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (brs, 1H), 7.52 – 7.47 (m, 2H), 7.46 – 7.43 (m, 1H), 7.39 – 7.35 (m, 2H), 7.34 – 7.27 (m, 5H), 7.20 – 7.15 (m, 1H), 7.03 – 6.98 (m, 1H), 4.65 (brs, 1H), 2.20 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.4, 136.6, 132.1, 129.3, 128.7, 128.4, 128.0, 125.9 (q, J = 284.2 Hz), 125.8, 123.0 (q, J = 2.3 Hz),122.8, 122.7, 122.5, 121.4, 120.0, 112.8, 111.3, 86.5 (q, J = 1.1 Hz), 86.4, 51.3 (q, J = 28.1 Hz), 16.3; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.4; HRMS (ESI) m/z calculated for $C_{26}H_{19}F_3NO$ [M - H]$^-$ 418.1424, found 418.1432; HPLC: the the ee value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 5/95, 1.0 mL/min, 241 nm), retention time: t_{minor} = 10.850 min, t_{major} = 16.043 min, ee = 90.5%; $[\alpha]_D^{30}$ = -67.4 (c = 0.99, $CHCl_3$).



(*S*)-2,6-Dimethyl-4-(1,1,1-trifluoro-2-(1*H*-indol-3-yl)oct-3-yn-2-yl)phenol (4l)

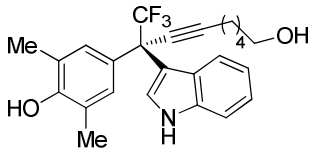
It was prepared using **3b** with 1.1 equiv of **2a** without K_2CO_3 additive and asymmetric nucleophilic addition was performed at 0 °C. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 73% (29.3 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 (brs, 1H), 7.37 – 7.28 (m, 3H), 7.22 (s, 2H), 7.19 – 7.13 (m, 1H), 7.00 – 6.94 (m, 1H), 2.31 (t, *J* = 7.0 Hz, 2H), 2.19 (s, 6H), 1.61 – 1.52 (m, 2H), 1.51 – 1.41 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.2, 136.6, 129.4, 128.5, 126.0 (q, *J* = 283.9 Hz), 125.8, 122.8 (q, *J* = 2.5 Hz), 122.5, 122.4, 121.6, 119.7, 113.4, 111.2, 77.32 – 77.28 (m), 87.2, 50.6 (q, *J* = 28.7 Hz), 30.7, 22.1, 18.7, 16.3, 13.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{24}H_{23}F_3NO$ [M - H]$^-$ 398.1737, found 398.1746; HPLC: the ee value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 5/95, 1.0 mL/min, 254 nm), retention time: t_{major} =7.550 min, t_{minor} = 8.260min, ee = 92.7%; $[\alpha]_D^{30}$ = +32.2 (c = 0.96, $CHCl_3$).



(*S*)-2,6-Dimethyl-4-(1,1,1-trifluoro-2-(1*H*-indol-3-yl)dec-3-yn-2-yl)phenol (4m)

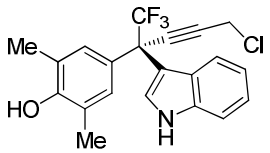
It was prepared using **3b** with 1.1 equiv of **2a** without K_2CO_3 additive and asymmetric nucleophilic addition was performed at 0 °C. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 71% (30.2 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 (brs, 1H), 7.37 – 7.29 (m, 3H), 7.22 (s, 2H), 7.19 – 7.14 (m, 1H), 7.00 – 6.94 (m, 1H), 4.64 (brs, 1H), 2.32 – 2.28 (m, 2H), 2.19 (s, 6H), 1.61 – 1.54 (m, 2H), 1.47 – 1.40 (m, 2H), 1.33 – 1.27 (m, 4H), 0.92 – 0.87 (m, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.2, 136.6, 129.4, 128.5, 126.0 (q, *J* = 283.9 Hz), 125.8, 122.8 (q, *J* = 2.4 Hz), 122.5, 122.4, 121.5, 119.7, 113.4, 111.2, 87.3, 77.35 – 77.30 (m), 50.6 (q, *J* = 29.0 Hz), 31.5, 28.7, 28.6, 22.8, 19.1, 16.3, 14.2; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{26}H_{27}F_3NO$ [M - H]$^-$ 426.2050, found 426.2062; HPLC: the ee

value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 3/97, 1.0 mL/min, 215 nm), retention time: t_{major} =11.460 min, t_{minor} = 13.030min, ee = 91.2%; $[\alpha]_D^{30}$ = +27.1 (c = 1.03, $CHCl_3$).



(*S*)-2,6-Dimethyl-4-(1,1,1-trifluoro-6-hydroxy-2-(1*H*-indol-3-yl)hex-3-yn-2-yl)phenol (4n)

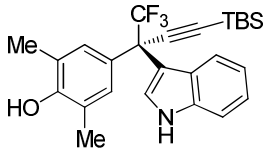
It was prepared using **3b** with 1.1 equiv of **2a** without K_2CO_3 additive and asymmetric nucleophilic addition was performed at 0 °C. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 70% (30.1 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (brs, 1H), 7.35 – 7.28 (m, 3H), 7.20 (s, 2H), 7.17 – 7.12 (m, *J* = 7.5 Hz, 1H), 6.98 – 6.93 (m, *J* = 7.6 Hz, 1H), 3.55 (t, *J* = 6.5 Hz, 2H), 2.32 (t, *J* = 6.8 Hz, 2H), 2.18 (s, 6H), 1.62 – 1.49 (m, 4H), 1.48 – 1.40 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.3, 136.6, 129.3, 128.4, 126.0 (q, *J* = 284.1 Hz), 125.8, 122.8 (q, *J* = 2.3 Hz), 122.6, 122.4, 121.5, 119.6, 113.3, 111.3, 86.8, 77.7 (q, *J* = 1.8 Hz), 63.0, 50.6 (q, *J* = 28.4 Hz), 32.4, 28.3, 25.0, 19.0, 16.3; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{25}H_{25}F_3NO_2$ $[M - H]^-$ 428.1843, found 428.1840; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 220 nm), retention time: t_{minor} =7.697 min, t_{major} = 9.317min, ee = 91.2%; $[\alpha]_D^{30}$ = +50.8 (c = 1.01, $CHCl_3$).



(*S*)-4-(5-Chloro-1,1,1-trifluoro-2-(1*H*-indol-3-yl)pent-3-yn-2-yl)-2,6-dimethylphenol (4o)

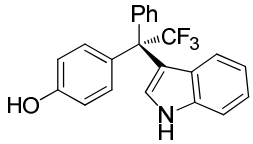
It was prepared using **3b** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 66% (25.7 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12 (brs, 1H), 7.37 – 7.32 (m, 2H), 7.29 (d, *J* = 8.1 Hz, 1H), 7.22 – 7.15 (m, 3H), 7.03 – 6.97 (m, 1H), 4.22 (d, *J* = 2.7 Hz, 2H), 2.19 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.5, 136.5, 129.2, 127.3, 125.6 (q, *J* = 284.3 Hz), 125.6, 123.2 (q, *J* = 2.6 Hz), 122.8, 122.6, 121.3, 120.1, 112.1, 111.4, 83.8 (q, *J* = 1.7 Hz), 81.2, 50.8 (q, *J* = 29.2 Hz), 30.7, 16.3; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.3; HRMS (ESI) m/z calculated for $C_{21}H_{16}ClF_3NO$ $[M - H]^-$ 390.0878, found 390.0887; HPLC:

the ee value was determined by HPLC analysis (Chiralpak AS-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 225 nm), retention time: t_{major} =15.707 min, t_{minor} = 19.847min, ee = 86.2%; $[\alpha]_D^{30}$ = +42.8 (c = 1.00, $CHCl_3$).



(*R*)-4-(4-(*tert*-Butyldimethylsilyl)-1,1,1-trifluoro-2-(1*H*-indol-3-yl)but-3-yn-2-yl)-2,6-dimethylphenol (4p)

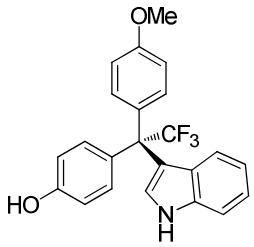
It was prepared using **3b** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 70% (31.8 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.94 (brs, 1H), 7.42 (d, *J* = 8.1 Hz, 1H), 7.30 – 7.21 (m, 4H), 7.20 – 7.14 (m, 1H), 7.04 – 6.96 (m, 1H), 2.19 (s, 6H), 1.01 (s, 9H), 0.15 (s, 3H), 0.13 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.3, 136.5, 129.4, 127.9, 125.7 (q, *J* = 284.2 Hz), 125.6, 123.1 (q, *J* = 2.5 Hz), 122.6, 122.5, 121.6, 119.7, 112.2, 111.3, 102.9, 90.2, 51.5 (q, *J* = 28.8 Hz), 26.3, 17.0, 16.3, -4.7, -4.7; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.5; HRMS (ESI) m/z calculated for $C_{26}H_{29}F_3NOSi$ $[M - H]^-$ 456.1976, found 456.1968; HPLC: the ee value was determined by HPLC analysis (ChiralcelOD-H, *i*-PrOH/hexane = 5/95, 1.0 mL/min, 254 nm), retention time: t_{major} =12.580 min, t_{minor} = 14.453min, ee = 93.1%; $[\alpha]_D^{30}$ = +60.8 (c = 1.02, $CHCl_3$).



(*S*)-4-(2,2,2-Trifluoro-1-(1*H*-indol-3-yl)-1-phenylethyl)phenol (6a)

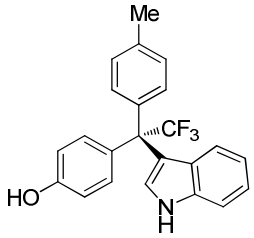
It was prepared using **3d** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 77% (28.2 mg). ^{1}H NMR (500 MHz, CD_3OD) δ 7.36 (d, *J* = 8.2 Hz, 1H), 7.32 – 7.23 (m, 5H), 7.10 (d, *J* = 8.7 Hz, 2H), 7.07 – 7.03 (m, 1H), 6.89 (d, *J* = 8.2 Hz, 1H), 6.82 – 6.78 (m, 1H), 6.72 (d, *J* = 8.9 Hz, 2H), 6.68 (s, 1H); ^{13}C NMR (126 MHz, CD_3OD) δ 157.8, 141.7, 138.6, 132.1, 131.9, 130.8, 129.7 (q, *J* = 285.8 Hz), 128.8, 128.4, 128.0, 127.6, 122.9, 122.5, 119.9, 116.3, 115.5, 112.4, 61.1 (q, *J* = 25.0 Hz); ^{19}F NMR (471 MHz,

CD_3OD) δ -61.9; HRMS (ESI) m/z calculated for $C_{22}H_{15}F_3NO$ $[M - H]^-$ 366.1111, found 366.1123; HPLC:the the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 227 nm), retention time: t_{major} = 20.460 min, t_{minor} = 24.720 min, ee = 93.2%; $[\alpha]_D^{30}$ = -1.8 (c = 0.97, $CHCl_3$).



(*R*)-4-(2,2,2-Trifluoro-1-(1*H*-indol-3-yl)-1-(4-methoxyphenyl)ethyl)phenol (6b)

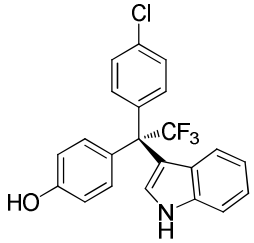
It was prepared using **3d** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 70% (27.8 mg). ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.20 (brs, 1H), 9.57 (brs, 1H), 7.40 (d, *J* = 8.2 Hz, 1H), 7.12 (d, *J* = 8.8 Hz, 2H), 7.07 – 7.02 (m, 1H), 7.00 (d, *J* = 8.7 Hz, 2H), 6.91 (d, *J* = 9.1 Hz, 2H), 6.83 – 6.79 (m, 1H), 6.77 – 6.71 (m, 4H), 3.75 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 158.3, 156.6, 136.9, 131.5, 130.3, 129.6, 129.6, 128.3 (q, *J* = 286.3 Hz), 126.8, 125.8, 121.1, 121.1, 118.8, 114.8, 114.2, 113.4, 111.9, 58.5 (q, *J* = 24.3 Hz), 55.0; ^{19}F NMR (471 MHz, DMSO-d_6) δ -60.5; HRMS (ESI) m/z calculated for $C_{23}H_{17}F_3NO_2$ $[M - H]^-$ 396.1217, found 396.1211; HPLC: the the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 230 nm), retention time: t_{major} = 8.960 min, t_{minor} = 10.687 min, ee = 91.2%; $[\alpha]_D^{30}$ = -1.6 (c = 0.11, $CHCl_3$).



(*S*)-4-(2,2,2-Trifluoro-1-(1*H*-indol-3-yl)-1-(*p*-tolyl)ethyl)phenol (6c)

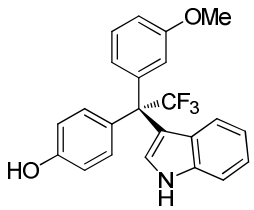
It was prepared using **3d** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 67% (25.7 mg). ^{1}H NMR (500 MHz, CD_3OD) δ 7.35 (d, *J* = 8.2 Hz, 1H), 7.19 – 7.15 (m, 2H), 7.11 – 7.02 (m, 5H), 6.91 – 6.87 (m, 1H), 6.81 – 6.77 (m, 1H), 6.72 – 6.66 (m, 3H), 2.32 – 2.28 (m, 3H); ^{13}C NMR (126 MHz, CD_3OD) δ

157.7, 138.7, 138.6, 138.2, 132.2, 132.1, 130.7, 129.8 (q, J = 285.5 Hz), 129.5, 127.9, 127.7, 123.0, 122.4, 119.9, 116.5, 115.5, 112.4, 60.8 (q, J = 24.6 Hz), 20.9; ^{19}F NMR (471 MHz, CD_3OD) δ -61.9; HRMS (ESI) m/z calculated for $C_{23}H_{17}F_3NO$ [M - H]$^-$ 380.1268, found 380.1263; HPLC:the the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 15/85, 0.3 mL/min, 215 nm), retention time: t_{major} =36.220 min, t_{minor} = 38.910min, ee = 90.3%; $[\alpha]_D^{30}$ = -2.3 (c = 1.04, $CHCl_3$).



(*R*)-4-(1-(4-Chlorophenyl)-2,2,2-trifluoro-1-(1*H*-indol-3-yl)ethyl)phenol (6d)

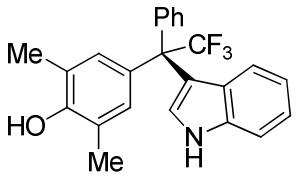
It was prepared using **3d** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 62% (24.7 mg). ^{1}H NMR (500 MHz, CD_3OD) δ 7.36 (d, J = 8.2 Hz, 1H), 7.30 – 7.27 (m, 4H), 7.11 – 7.04 (m, 3H), 6.88 – 6.80 (m, 2H), 6.74 – 6.69 (m, 3H); ^{13}C NMR (126 MHz, CD_3OD) δ 158.1, 140.5, 138.6, 134.6, 132.5, 132.0, 131.4, 129.53 (q, J = 285.6 Hz), 129.0, 128.0, 127.4, 122.7, 122.6, 120.1, 115.8, 115.7, 112.5, 60.8 (q, J = 25.1 Hz); ^{19}F NMR (471 MHz, CD_3OD) δ -61.8; HRMS (ESI) m/z calculated for $C_{22}H_{14}ClF_3NO$ [M - H]$^-$ 400.0721, found 400.0713; HPLC: the the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 15/85, 0.8 mL/min, 215 nm), retention time: t_{major} =10.847 min, t_{minor} = 12.213min, ee = 91.0%; $[\alpha]_D^{30}$ = -4.1 (c = 1.00, $CHCl_3$).



(*R*)-4-(2,2,2-Trifluoro-1-(1*H*-indol-3-yl)-1-(3-methoxyphenyl)ethyl)phenol (6e)

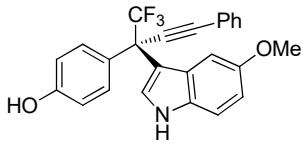
It was prepared using **3d** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 58% (23.0 mg). ^{1}H NMR (500 MHz, CD_3OD) δ 7.36 (d, J = 8.2 Hz, 1H), 7.23 – 7.16 (m, 1H), 7.12 – 7.03 (m, 3H), 6.94 – 6.88 (m, 2H), 6.88 – 6.79 (m, 3H), 6.73 – 6.69 (m, 3H), 3.63 – 3.60 (m, 3H); ^{13}C NMR (126 MHz, CD_3OD) δ

160.7, 157.8, 143.2, 138.6, 132.1, 131.9, 129.7, 129.7 (q, J = 285.6 Hz), 128.0, 127.6, 123.2, 122.9, 122.5, 119.9, 117.4, 116.2, 115.5, 113.4, 112.4, 61.1 (q, J = 25.3 Hz), 55.5; ^{19}F NMR (471 MHz, CD_3OD) δ -61.8; HRMS (ESI) m/z calculated for $C_{23}H_{17}F_3NO_2$ [M - H]$^-$ 396.1217, found 396.1219; HPLC: the the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 15/85, 1.0 mL/min, 232 nm), retention time: t_{major} =11.793 min, t_{minor} = 13.543min, ee = 91.0%; $[\alpha]_D^{30}$ = -1.2 (c = 0.92, $CHCl_3$).



(*S*)-2,6-Dimethyl-4-(2,2,2-trifluoro-1-(1*H*-indol-3-yl)-1-phenylethyl)phenol (6f)

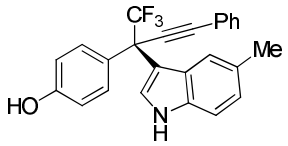
It was prepared using **3d** with 1.1 equiv of **2a** without K_2CO_3 additive. Then it was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 77% (30.3 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.11 (brs, 1H), 7.38 – 7.30 (m, 6H), 7.19 – 7.15 (m, 1H), 7.06 – 7.02 (m, 1H), 6.97 – 6.91 (m, 3H), 6.70 – 6.67 (m, 1H), 2.16 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 151.7, 140.3, 136.9, 131.4, 130.2 (q, J = 2.0 Hz), 129.9 (q, J = 2.0 Hz), 128.4 (q, J = 286.6 Hz), 128.1, 127.6, 126.9, 126.6, 122.7 (q, J = 3.0 Hz), 122.5, 122.3, 120.0, 116.7, 111.3, 60.1 (q, J = 25.0 Hz), 16.4; ^{19}F NMR (471 MHz, $CDCl_3$) δ -60.3; HRMS (ESI) m/z calculated for $C_{24}H_{19}F_3NO$ [M - H]$^-$ 394.1424, found 394.1432; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 215 nm), retention time: t_{major} = 13.397 min, t_{minor} = 14.537 min, ee = 96.5%; $[\alpha]_D^{30}$ = -3.6 (c = 1.01, $CHCl_3$).



(*S*)-4-(1,1,1-Trifluoro-2-(5-methoxy-1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (7a)

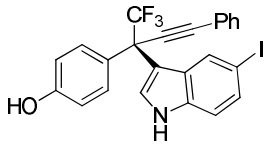
It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 88% (37.1mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.1 (brs, 1H), 7.55 – 7.51 (m, 2H), 7.50 – 7.46 (m, 2H), 7.38 – 7.35 (m, 1H), 7.33 – 7.28 (m, 3H), 7.26 – 7.24 (m, 1H), 6.85 – 6.81 (m, 1H), 6.79 – 6.75 (m, 3H), 3.61 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.5, 153.8, 131.9, 131.5, 130.5, 128.8, 128.6, 128.3, 126.1, 125.6 (q, J = 284.2 Hz), 123.5 (q, J = 2.7 Hz), 122.5, 115.0, 112.7, 112.1, 111.8, 102.9,

86.3, 86.0 (q, J = 1.9 Hz), 55.7, 51.0 (q, J = 29.2 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.6; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO_2$ [M - H]$^-$ 420.1217, found 420.1215; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 215nm), retention time: t_{minor} = 8.703 min, t_{major} = 10.577 min, ee = 95.3%; $[\alpha]_D^{30}$ = -112.5 (c = 1.08, $CHCl_3$).



(*S*)-4-(1,1,1-Trifluoro-2-(5-methyl-1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (7b)

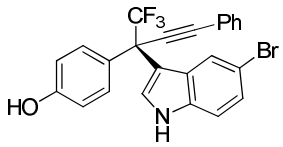
It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 85% (34.3 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (brs, 1H), 7.54 (d, J = 8.6 Hz, 2H), 7.51 – 7.47 (m, 2H), 7.35 – 7.29 (m, 4H), 7.25 (d, J = 8.3 Hz, 1H), 7.19 (s, 1H), 7.01 (dd, J = 8.3, 1.3 Hz, 1H), 6.76 (d, J = 8.8 Hz, 2H), 2.32 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.6, 134.9, 132.0, 130.6, 129.2, 129.1, 128.8, 128.5, 125.9, 125.8 (q, J = 284.2 Hz), 124.3, 123.3 (q, J = 2.6 Hz), 122.7, 120.9, 115.2, 111.9, 111.0, 86.5– 86.4 (m), 51.3 (q, J = 29.2 Hz), 21.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.5; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO$ [M - H]$^-$ 404.1268, found 404.1263; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 239 nm), retention time: t_{minor} = 25.420 min, t_{major} = 27.323 min, ee = 90.3%; $[\alpha]_D^{30}$ = -146.5 (c = 1.03, $CHCl_3$).



(*S*)-4-(1,1,1-Trifluoro-2-(5-iodo-1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (7c)

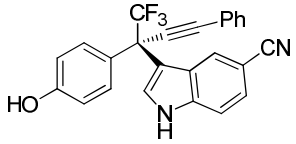
It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 82% (42.2 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.20 (brs, 1H), 7.83 – 7.79 (m, 1H), 7.54 – 7.48 (m, 4H), 7.44 – 7.41 (m, 1H), 7.36 – 7.30 (m, 4H), 7.16 – 7.11 (m, 1H), 6.79 (d, J = 8.7 Hz, 2H), 4.97 (brs, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.7, 135.5, 131.9, 131.0, 130.4, 129.9, 128.8, 128.4, 128.0, 125.4 (q, J = 284.1 Hz), 123.6 (q, J = 2.5 Hz), 122.2, 115.2, 113.3, 111.8, 86.8, 85.7 (q, J = 1.7 Hz), 83.6, 50.9 (q, J = 29.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7; HRMS (ESI) m/z calculated for $C_{24}H_{14}F_3INO$ [M - H]$^-$ 516.0078, found 516.0086; HPLC: the ee value was determined by HPLC analysis

(Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 254 nm), retention time: t_{major} = 5.477 min, t_{minor} = 8.657 min, ee = 95.1%; $[\alpha]_D^{30}$ = -122.2 (c = 1.01, $CHCl_3$).



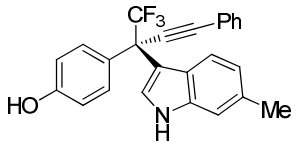
(*S*)-4-(2-(5-Bromo-1*H*-indol-3-yl)-1,1,1-trifluoro-4-phenylbut-3-yn-2-yl)phenol (7d)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 80% (37.5 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.24 (brs, 1H), 7.55 (s, 1H), 7.53 – 7.46 (m, 4H), 7.41 – 7.39 (m, 1H), 7.35 – 7.30 (m, 3H), 7.26 – 7.25 (m, 2H), 6.79 (d, *J* = 8.8 Hz, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.7, 135.1, 131.9, 130.4, 128.8, 128.4, 128.4, 127.3, 125.5, 125.4 (q, *J* = 284.2 Hz), 124.0 (q, *J* = 2.8 Hz), 123.6, 122.2, 115.2, 113.3, 112.7, 112.2, 86.7, 85.6 (q, *J* = 1.9 Hz), 50.9 (q, *J* = 29.5 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.7; HRMS (ESI) m/z calculated for $C_{24}H_{14}BrF_3NO$ $[M - H]^-$ 468.0216, found 468.0220; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 236 nm), retention time: t_{major} = 5.623 min, t_{minor} = 6.840 min, ee = 95.4%; $[\alpha]_D^{30}$ = -125.0 (c = 1.04, $CHCl_3$).



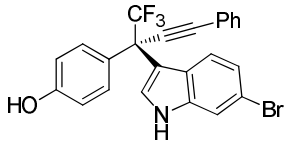
(*S*)-3-(1,1,1-Trifluoro-2-(4-hydroxyphenyl)-4-phenylbut-3-yn-2-yl)-1*H*-indole-5-carbonitrile (7e)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 76% (31.8 mg). ^{1}H NMR (600 MHz, CD_3OD) δ 7.60 – 7.56 (m, 2H), 7.56 – 7.53 (m, 1H), 7.47 – 7.41 (m, 4H), 7.39 – 7.33 (m, 4H), 6.79 (d, *J* = 8.9 Hz, 2H); ^{13}C NMR (151 MHz, CD_3OD) δ 159.1, 140.1, 132.6, 131.2, 130.1, 129.7, 128.1, 127.1, 126.9 (q, *J* = 283.3 Hz), 126.7, 125.6, 123.3, 121.5, 116.1, 114.0, 113.9, 103.0, 87.8, 86.9 (q, *J* = 1.4 Hz), 52.2 (q, *J* = 29.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.0; HRMS (ESI) m/z calculated for $C_{25}H_{14}F_3N_2O$ $[M - H]^-$ 415.1064, found 415.1069; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 247 nm), retention time: t_{major} = 4.800 min, t_{minor} = 5.500 min, ee = 92.8%; $[\alpha]_D^{30}$ = -124.9 (c = 1.01, THF).



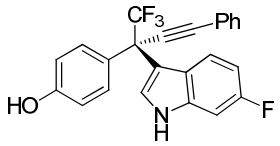
(*S*)-4-(1,1,1-Trifluoro-2-(6-methyl-1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (7f)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 81% (32.8 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (brs, 1H), 7.53 (d, *J* = 8.6 Hz, 2H), 7.49 – 7.46 (m, 2H), 7.34 – 7.28 (m, 4H), 7.21 (d, *J* = 8.2 Hz, 1H), 7.16 (s, 1H), 6.82 (dd, *J* = 8.2, 0.8 Hz, 1H), 6.76 (d, *J* = 8.8 Hz, 2H), 4.84 (brs, 1H), 2.41 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.7, 137.1, 132.5, 132.1, 130.7, 129.2, 128.8, 128.4, 125.8 (q, *J* = 284.3 Hz), 123.6, 122.7, 122.5 (q, *J* = 2.6 Hz), 121.9, 120.9, 115.2, 112.5, 111.3, 86.4, 86.4, 51.2 (q, *J* = 29.2 Hz), 21.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.6; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO$ $[M - H]^-$ 404.1268, found 404.1259; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 215 nm), retention time: t_{minor} = 8.347 min, t_{major} = 11.900 min, ee = 95.8%; $[\alpha]_D^{30}$ = -113.3 (c = 0.97, $CHCl_3$).



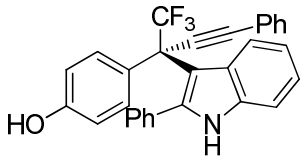
(*S*)-4-(2-(6-Bromo-1*H*-indol-3-yl)-1,1,1-trifluoro-4-phenylbut-3-yn-2-yl)phenol (7g)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 78% (36.7 mg). ^{1}H NMR (600 MHz, CD_3OD) δ 7.55 (d, *J* = 1.5 Hz, 1H), 7.44 – 7.38 (m, 5H), 7.36 – 7.31 (m, 3H), 7.11 (d, *J* = 8.6 Hz, 1H), 6.98 (dd, *J* = 8.6, 1.8 Hz, 1H), 6.75 (d, *J* = 8.9 Hz, 2H); ^{13}C NMR (151 MHz, CD_3OD) δ 158.8, 139.1, 132.7, 131.3, 129.9, 129.6, 128.5, 127.1 (q, *J* = 283.1 Hz), 125.8, 125.2 (q, *J* = 2.2 Hz), 123.6, 123.2, 123.0, 116.3, 115.8, 115.4, 113.0, 87.3, 87.3, 52.2 (q, *J* = 29.2 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -67.1; HRMS (ESI) m/z calculated for $C_{24}H_{14}BrF_3NO$ $[M - H]^-$ 468.0216, found 468.0214; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 215 nm), retention time: t_{minor} = 6.293 min, t_{major} = 8.167 min, ee = 95.0%; $[\alpha]_D^{30}$ = -136.9 (c = 1.01, THF).



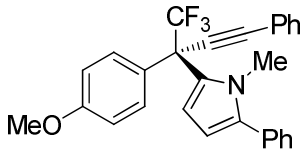
(*S*)-4-(1,1,1-Trifluoro-2-(6-fluoro-1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (7h)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 75% (30.7 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (brs, 1H), 7.53 – 7.49 (m, 2H), 7.48 – 7.45 (m, 2H), 7.39 – 7.37 (m, 1H), 7.34 – 7.28 (m, 3H), 7.25 – 7.22 (m, 1H), 7.07 – 7.04 (m, 1H), 6.80 – 6.72 (m, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.3 (d, *J* = 238.9 Hz), 155.9, 136.6 (d, *J* = 12.3 Hz), 132.1, 130.7, 128.9, 128.9, 128.5, 125.7 (q, *J* = 284.7 Hz), 123.4 (q, *J* = 2.5 Hz), 122.5, 122.3, 122.1 (d, *J* = 10.1 Hz), 115.2, 112.9, 109.1 (d, *J* = 24.4 Hz), 97.7 (d, *J* = 26.2 Hz), 86.7, 86.1 (q, *J* = 1.7 Hz), 51.2 (q, *J* = 29.7 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8, -120.5; HRMS (ESI) m/z calculated for $C_{24}H_{14}F_4NO$ $[M - H]^-$ 408.1017, found 408.1007; HPLC: the ee value was determined by HPLC analysis (Chiralpak IB, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 218 nm), retention time: t_{minor} = 12.190 min, t_{major} = 13.153 min, ee = 93.1%; $[\alpha]_D^{30}$ = -168.1 (c = 1.05, $CHCl_3$).



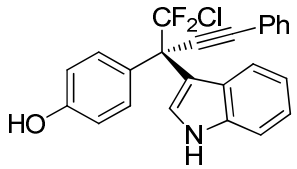
(*S*)-4-(1,1,1-Trifluoro-4-phenyl-2-(2-phenyl-1*H*-indol-3-yl)but-3-yn-2-yl)phenol (7i)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 70% (32.6 mg).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 (brs, 1H), 7.54 (d, *J* = 8.3 Hz, 1H), 7.43 (d, *J* = 8.5 Hz, 2H), 7.36 – 7.31 (m, 3H), 7.28 – 7.17 (m, 7H), 7.13 – 7.10 (m, 2H), 7.07 – 7.03 (m, 1H), 6.64 (d, *J* = 8.8 Hz, 2H), 5.03 (brs, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 154.9, 138.7, 135.1, 133.9, 131.9, 131.6, 130.6, 130.0, 128.5, 128.3, 128.0, 127.7, 127.1, 126.2 (q, *J* = 284.5 Hz), 122.6, 122.4, 122.3 (q, *J* = 2.2 Hz), 120.3, 115.1, 110.8, 109.2, 87.8 (q, *J* = 2.3 Hz), 87.6, 51.6 (q, *J* = 29.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -67.0; HRMS (ESI) m/z calculated for $C_{30}H_{19}F_3NO$ $[M - H]^-$ 466.1424, found 466.1431; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 20/80, 1.0 mL/min, 237 nm), retention time: t_{major} = 6.660 min, t_{minor} = 7.757 min, ee = 92.3%; $[\alpha]_D^{30}$ = -16.2 (c = 1.04, $CHCl_3$).



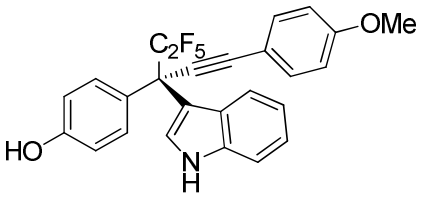
1-Methyl-2-phenyl-5-(1,1,1-trifluoro-2-(4-methoxyphenyl)-4-phenylbut-3-yn-2-yl)-1*H*-pyrrole (9')

9 was prepared using **3d** with 1.0 equiv of **8** without K_2CO_3 additive. The mixture was treated with NaH and MeI for purification due to the product instability issue. Yield: 65% (29.0 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 – 7.54 (m, 2H), 7.51 (d, *J* = 8.6 Hz, 2H), 7.41 – 7.34 (m, 7H), 7.33 – 7.29 (m, 1H), 6.93 (d, *J* = 8.9 Hz, 2H), 6.56 – 6.53 (m, 1H), 6.28 (d, *J* = 3.8 Hz, 1H), 3.84 (s, 3H), 3.28 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.1, 136.9, 133.4, 132.1, 130.4, 129.5, 129.1, 128.6, 128.5, 127.9, 127.3, 127.2, 125.1 (q, *J* = 284.1 Hz), 122.3, 114.0, 109.0 (q, *J* = 2.9 Hz), 107.8, 87.3, 84.7, 55.5, 52.4 (q, *J* = 28.9 Hz), 33.7; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.4; HRMS (ESI) m/z calculated for $C_{28}H_{23}F_3NO$ $[M + H]^+$ 446.1726, found 446.1739; HPLC: the ee value was determined by HPLC analysis (Chiralcel OD-H, *i*-PrOH/hexane = 0.5/99.5, 1.0 mL/min, 279 nm), retention time: t_{minor} =7.360 min, t_{major} = 8.460 min, ee = 93.1%; $[\alpha]_D^{30}$ = -13.3 (c = 0.92, $CHCl_3$).



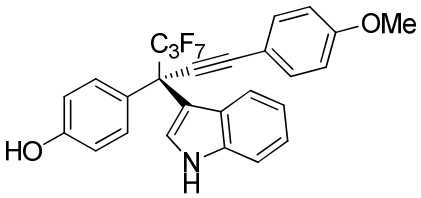
(*S*)-4-(1-Chloro-1,1-difluoro-2-(1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (11a)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 63% (25.8mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16 (brs, 1H), 7.56 (d, *J* = 8.6 Hz, 2H), 7.51 – 7.44 (m, 3H), 7.41 – 7.28 (m, 5H), 7.20 – 7.14 (m, 1H), 7.02 – 6.96 (m, 1H), 6.75 (d, *J* = 8.8 Hz, 2H), 4.95 (brs, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.7, 136.4, 132.0, 131.2, 130.9 (t, *J* = 300.6 Hz),129.7, 128.8, 128.5, 126.0, 123.4 (t, *J* = 3.3 Hz), 122.7, 122.6, 121.4, 120.0, 115.0, 113.2, 111.3, 87.4 (t, *J* = 3.1 Hz), 87.2, 56.7 (t, *J* = 25.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -54.50 – -56.79 (m, 2F); HRMS (ESI) m/z calculated for $C_{24}H_{15}ClF_2NO$ $[M - H]^-$ 406.0816, found 406.0809; HPLC: the ee value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 254 nm), retention time: t_{minor} = 6.623 min, t_{major} = 15.933min, ee = 84.1%; $[\alpha]_D^{30}$ = -21.5 (c = 1.04, $CHCl_3$).



(*S*)-4-(4,4,5,5,5-Pentafluoro-3-(1*H*-indol-3-yl)-1-phenylpent-1-yn-3-yl)phenol (11b)

It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 68% (32.1mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.13 (brs, 1H), 7.59 (d, *J* = 7.6 Hz, 2H), 7.45 – 7.31 (m, 5H), 7.18 – 7.12 (m, 1H), 7.00 – 6.94 (m, 1H), 6.83 (d, *J* = 8.9 Hz, 2H), 6.75 (d, *J* = 8.9 Hz, 2H), 5.12 (brs, 1H), 3.80 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.1, 155.7, 136.5, 133.4, 130.8, 128.7, 125.9, 123.2 (t, *J* = 4.6 Hz), 122.5, 121.5, 119.9, 124.1 – 112.7 (m), 115.1, 114.8, 114.1, 113.1, 111.3, 88.1, 84.4 – 84.2 (m), 55.5, 50.2 – 49.7 (m); ^{19}F NMR (471 MHz, $CDCl_3$) δ -76.5 – -76.6 (m, 3F), -110.0 – -115.7 (m, 2F); HRMS (ESI) m/z calculated for $C_{26}H_{17}F_5NO_2$ $[M - H]^-$ 470.1185, found 470.1188; HPLC: the ee value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 256 nm), retention time: t_{minor} =7.460 min, t_{major} = 13.857min, ee = 91.1%; $[\alpha]_D^{30}$ = -88.3 (c = 1.04, $CHCl_3$).



(*S*)-4-(4,4,5,5,6,6,6-Heptafluoro-3-(1*H*-indol-3-yl)-1-(4-methoxyphenyl)hex-1-yn-3-yl)phenol (11c)

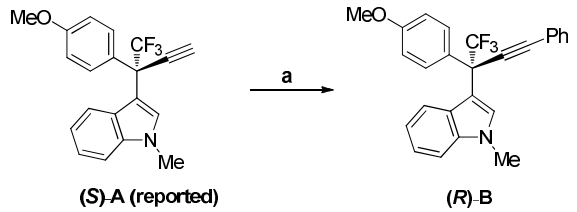
It was purified by silica gel chromatography using EtOAc/petroleum ether (1:4). Yield: 66% (34.3 mg). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 (brs, 1H), 7.62 (d, *J* = 8.4 Hz, 2H), 7.49 (d, *J* = 8.1 Hz, 1H), 7.40 (d, *J* = 8.7 Hz, 2H), 7.33 (s, 1H), 7.30 (d, *J* = 8.2 Hz, 1H), 7.18 – 7.14 (m, 1H), 7.03 – 6.98 (m, 1H), 6.84 (d, *J* = 8.7 Hz, 2H), 6.74 (d, *J* = 8.8 Hz, 2H), 5.21 (brs, 1H), 3.80 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.0, 155.6, 136.5, 133.4, 131.0, 128.5, 125.8, 123.3, 122.5, 121.5, 119.9, 122.9 – 107.5 (m), 115.1, 114.8, 114.2, 113.1, 111.4, 88.2, 84.3 – 84.2 (m), 55.5, 50.9 (t, *J* = 23.7 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -80.9 – -81.0 (m, 3F), -106.2 – -109.8 (m, 2F), -117.8 – -121.3 (m, 2F); HRMS (ESI) m/z calculated for $C_{27}H_{17}F_7NO_2$ $[M - H]^-$ 520.1153 found 520.1149; HPLC: the ee

value was determined by HPLC analysis (Chiralpak IG, *i*-PrOH/hexane = 10/90, 1.0 mL/min, 253 nm), retention time: t_{minor} = 5.647 min, t_{major} = 8.487 min, ee = 93.0%; $[\alpha]_D^{30}$ = -56.6 (c = 1.01, $CHCl_3$).

Absolute configuration determination

Absolute configuration determination of 4a

The absolute configuration of **4a** was determined by preparing the same product **B** from the reported optical pure substrate (*S*)-**A** and **4a** respectively.[5-6]

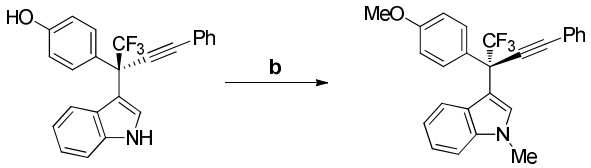


(*S*)-A (reported) (*R*)-B

Regent and condition: (a) iodobenzene (1.1 equiv), $PdCl_2(PPh_3)_2$ (0.02 equiv), CuI (0.015mml, 0.05 equiv), THF/Et_3N (1 mL/ 1 mL), N_2, 60 ℃, 12 h.

(*R*)-1-Methyl-3-(1,1,1-trifluoro-2-(4-methoxyphenyl)-4-phenylbut-3-yn-2-yl)-1*H*-indole (B)

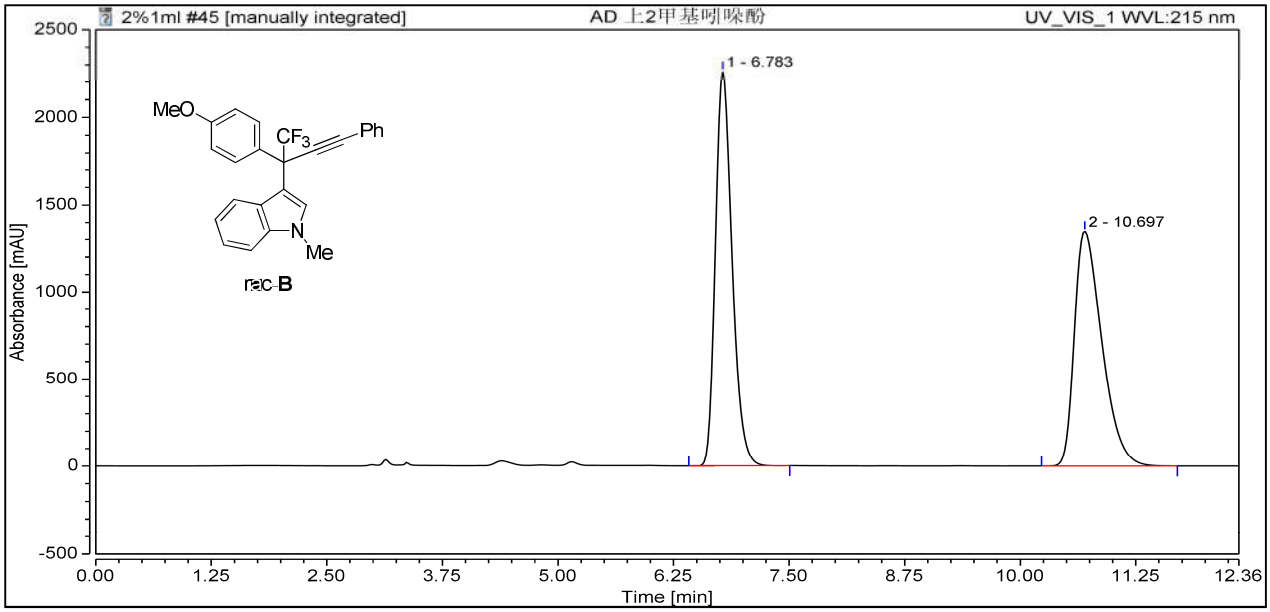
Prepared starting from (*S*)-**A** according to procedure **a**. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.59 (d, *J* = 8.8 Hz, 2H), 7.50 – 7.45 (m, 2H), 7.35 – 7.27 (m, 5H), 7.26 – 7.24 (m, 1H), 7.22 – 7.18 (m, 1H), 6.99 – 6.95 (m, 1H), 6.85 (d, *J* = 8.9 Hz, 2H), 3.84 (s, 3H), 3.79 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.7, 137.5, 132.1, 130.4, 129.0, 128.7, 128.4, 127.7 (q, *J* = 2.6 Hz), 126.3, 125.9 (q, *J* = 284.4 Hz), 122.8, 122.1, 121.4, 119.6, 113.6, 110.9, 109.5, 86.5 (q, *J* = 1.2 Hz), 86.4, 55.4, 51.2 (q, *J* = 29.1 Hz), 33.2; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.6; HRMS (ESI) m/z calculated for $C_{26}H_{21}F_3NO$ $[M+H]^+$ 420.1570, found 420.1566; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, i-PrOH/hexane = 2/98, 1.0 mL/min, 215nm), retention time: t_{major} = 6.753 min, t_{minor} = 10.740 min, ee = 88.8%; $[\alpha]_D^{30}$ = +98.3 (c = 0.50, $CHCl_3$).



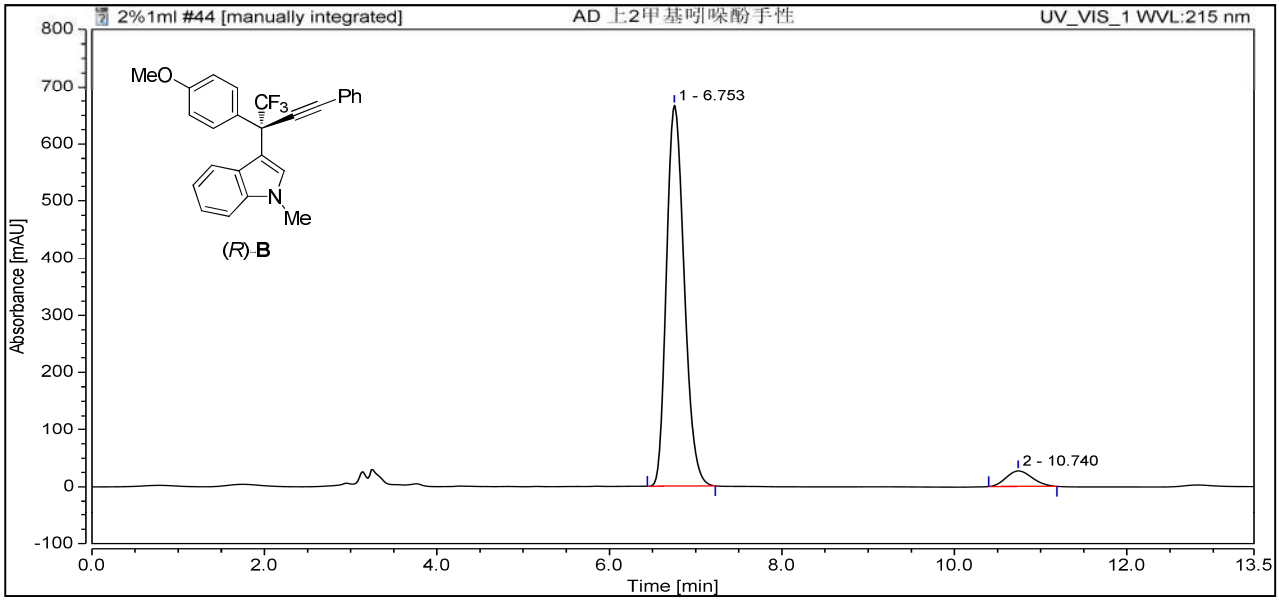
(*S*)-4a (*S*)-B

Regent and condition: (**b**) MeI (5.0 equiv), NaH (2.5 equiv), THF.

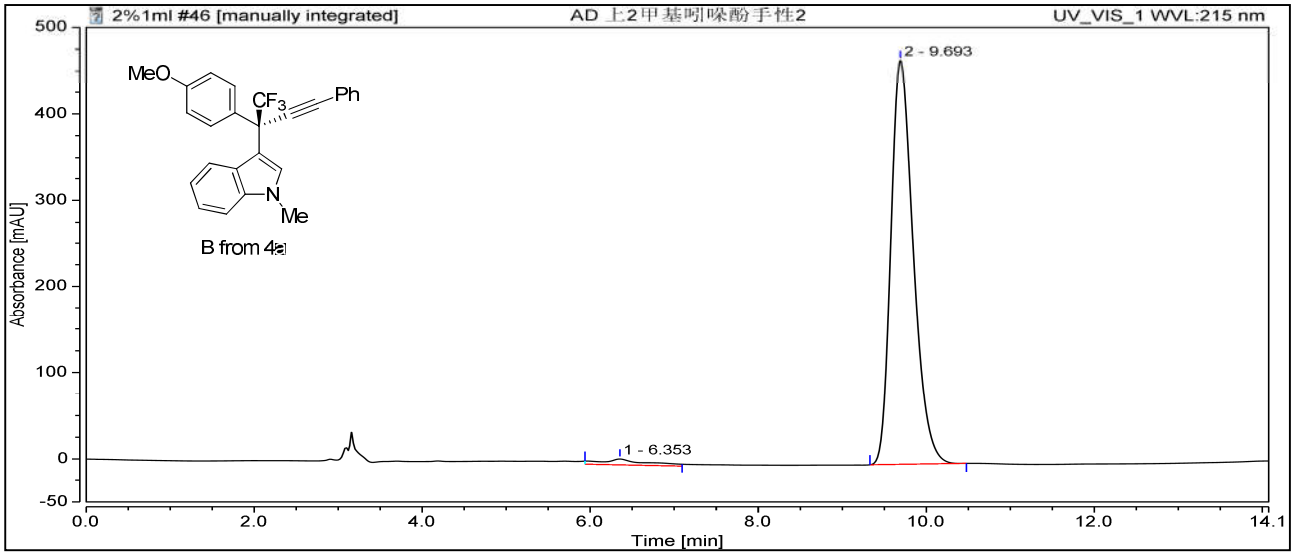
Prepared starting from **4a** according to procedure **b.** ^{1}H NMR, ^{13}C NMR and ^{19}F NMR were the same as the (*R*)-**B** above. HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, *i*-PrOH/hexane = 2/98, 1.0 mL/min, 215 nm), retention time: t_{minor} = 6.353 min, t_{major} = 9.693 min, ee = 94.4%; $[\alpha]_D^{30}$ = -120.2 (c = 0.22, $CHCl_3$). The results of HPLC and $[\alpha]_D$ were opposite to (*R*)-**B**, which allowed the assignment of the absolute configuration of **4a** as *S* according to the known literature.



Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.783	472.765	50.48	n.a.
2		10.697	463.867	49.52	n.a.
Total:			**936.632**	**100.00**	



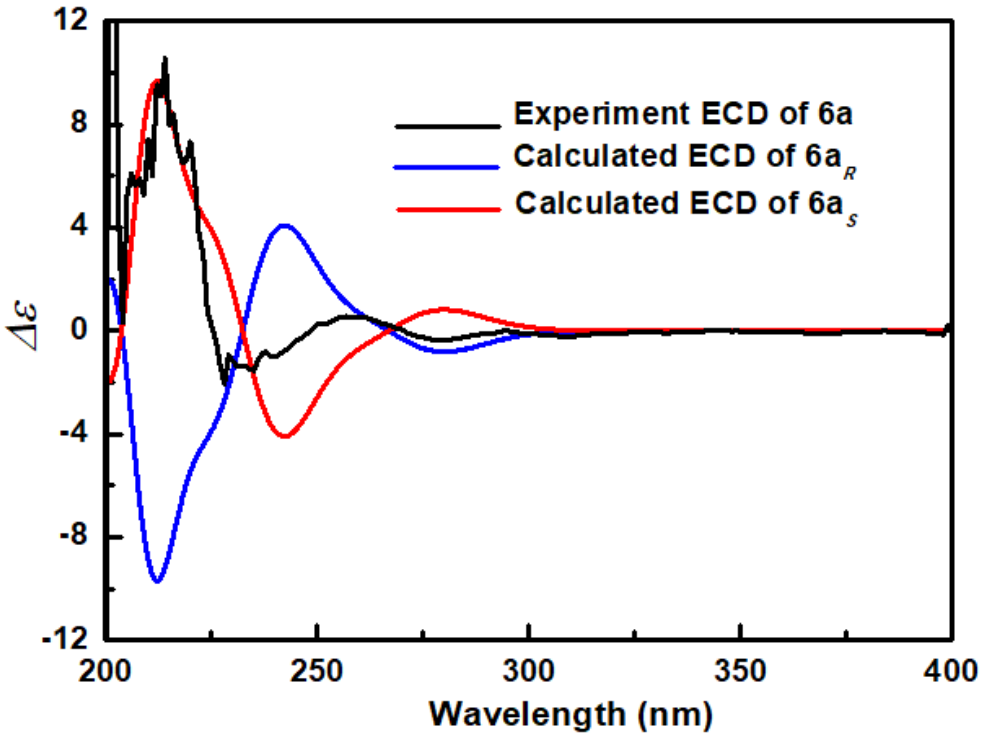
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.753	158.969	94.41	n.a.
2		10.740	9.409	5.59	n.a.
Total:			**168.378**	**100.00**	

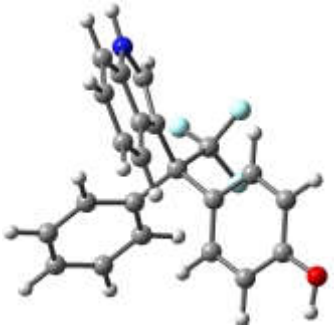


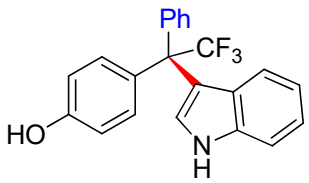
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.353	4.201	2.82	n.a.
2		9.693	144.613	97.18	n.a.
Total:			**148.814**	**100.00**	

Absolute configuration determination of 6a

The absolute configuration of **6a** was determined to be *S* on the basis of UV and circular dichroism (CD) analyses. The simulated electrostatic circular dichroism (ECD) curve of (*S*)-**6a** and (*R*)-**6a** through DFT calculation were correspondingly expressed as the red curve $\mathbf{6a}_{S}$ and the blue curve $\mathbf{6a}_{R}$. The experiment ECD curve of **6a** through handling the experimental data from UV and CD spectra was expressed as the black curve **6a**. According to the figure shown below, the trend of the experiment ECD curve of **6a** was consistent with the simulated ECD curve of $\mathbf{6a}_{S}$, which allowed the assignment of the absolute configuration of **6a** as *S*.







6a

(*S*)-4-(2,2,2-trifluoro-1-(1*H*-indol-3-yl)-1-phenylethyl)phenol

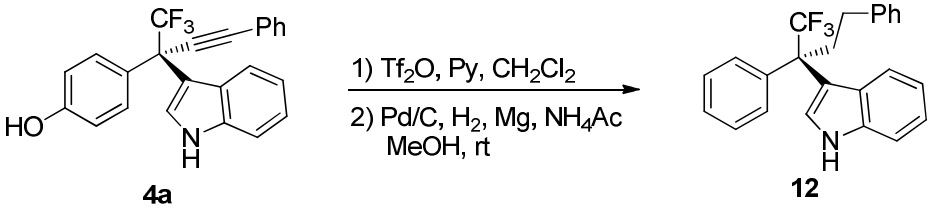
Computational methods:

The calculations were conducted using density functional theory (DFT) as implemented in the gaussian 09.[7] Geometry optimization and frequency calculation were carried out at the B3LYP/6-31G* level. Electronic excitation energies and rotational strengths in methanol were calculated using TDDFT at cam-B3LYP/PCM-6-31+G(d,p) level in velocity formalism for the first 50 states. The CD curves were simulated by using the Gaussian function:[8]

$$\Delta\varepsilon(E) = \frac{1}{2.296\times10^{-39}}\frac{1}{\sigma\sqrt{\pi}}\times\sum_{i}\Delta E_i R_i e^{-[(E-\Delta E_i)/\sigma]^2}$$

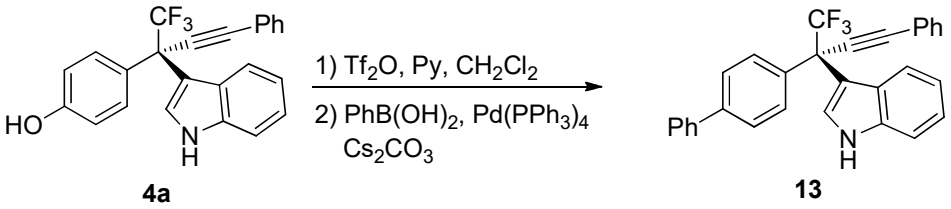
where σ is the width of the band at $1/e$ height and ΔEi and Ri are the excitation energies and rotatory strengths for transition i, respectively. Here a value of $\sigma = 0.6$ eV.

Synthetic application



(*R*)-3-(1,1,1-Trifluoro-2,4-diphenylbutan-2-yl)-1*H*-indole (12)

To a solution of **4a** (0.1 mmol, 1.0 equiv) in CH_2Cl_2 (5 mL) were added pyridine (0.2 mmol, 2.0 equiv) and a solution of Tf_2O (0.115 mmol, 1.15 equiv) in CH_2Cl_2 (0.5 mL) sequentially. The reaction mixture was stirred for 2 h. Then water (10 mL) was added. The layers were separated, and the aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using EtOAc/petroleum ether (1:10) as eluent. Then a mixture of the product, 10% Pd/C (9.3 mg, 10 wt %), NH_4OAc (15.4 mg), and Mg (12.0 mg) in methanol (5.0 mL) was stirred at room temperature under hydrogen balloon for 12 h. The mixture was passed through a short length of silica gel using EtOAc/petroleum ether (1:10) as eluent to afford **12** (32.6 mg, 86% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 (brs, 1H), 7.44 – 7.41 (m, 2H), 7.39 – 7.35 (m, 2H), 7.30 – 7.26 (m, 3H), 7.24 – 7.20 (m, 2H), 7.17 – 7.13 (m, 2H), 7.03 – 7.01 (m, 2H), 6.91 – 6.87 (m, 1H), 6.81 – 6.78 (m, 1H), 2.88 – 2.76 (m, 2H), 2.64 – 2.55 (m, 1H), 2.38 – 2.29 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 142.4, 139.1, 136.6, 129.3, 128.6, 128.6, 128.3 (q, J = 285.1 Hz), 128.2, 127.8, 126.1, 124.3 (q, J = 2.2 Hz), 122.4, 121.6, 119.9, 114.0, 111.4, 53.8 (q, J = 24.5 Hz), 38.3, 31.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -68.1; HRMS (EI) m/z calculated for $C_{24}H_{21}F_3N$ $[M + H]^+$: 380.1621, found 380.1623; HPLC: the ee value was determined by HPLC analysis (Chiralpak IG, i-PrOH/hexane = 5/95, 1 mL/min, 215 nm), retention time: t_{major} = 9.737 min, t_{minor}= 11.590 min, ee = 93.4%; $[\alpha]_D^{30}$ = +8.5 (c = 0.96, $CHCl_3$).



4a **13**

(*S*)-3-(2-([1,1'-Biphenyl]-4-yl)-1,1,1-trifluoro-4-phenylbut-3-yn-2-yl)-1*H*-indole (13)

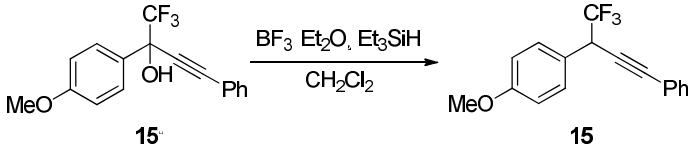
To a solution of **4a** (0.1 mmol, 1.0 equiv) in CH_2Cl_2 (5 mL) were added pyridine (0.2 mmol, 2.0 equiv) and a solution of Tf_2O (0.115 mmol, 1.15 equiv) in CH_2Cl_2 (0.5 mL) sequentially. The reaction mixture was stirred for 2 h. Then water (10 mL) was added. The layers were separated, and the aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous Na_2SO_4, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using EtOAc/petroleum ether (1:10) as eluent. Then to a solution of the product, phenylboronic acid (0.15 mmol, 1.5 equiv), Cs_2CO_3 (97.7 mg, 0.3 mmol, 3 equiv) in dioxane (1 mL) was added $Pd(PPh_3)_4$ (17.3 mg, 0.015 mmol, 0.15 equiv) and degassed with nitrogen. The reaction mixture was stirred at 60 ℃ for 48 h and then filtered through a short pad of celite, which was washed with CH_2Cl_2 (10 mL). The filtrate was concentrated and the residue was purified by flash chromatography on silica gel using EtOAc/petroleum ether (1:50) as eluent to afford **13** (38.9 mg, 86% yield). ^{1}H NMR (500 MHz, CD_3OD) δ 7.71 (d, J = 8.3 Hz, 2H), 7.61 – 7.56 (m, 4H), 7.47 – 7.44 (m, 3H), 7.41 – 7.37 (m, 3H), 7.35 – 7.28 (m, 4H), 7.26 (d, J = 8.1 Hz, 1H), 7.10 – 7.06 (m, 1H), 6.88 – 6.84 (m, 1H); ^{13}C NMR (126 MHz, CD_3OD) δ 142.5, 141.6, 138.3, 137.3, 132.7, 130.6, 129.9, 129.9, 129.6, 128.6, 128.1, 127.7, 127.1 (q, J = 283.3 Hz), 126.7, 124.5 (q, J = 2.3 Hz), 123.6, 122.9, 121.5, 120.1, 112.5, 112.0, 87.5, 87.2 (q, J = 1.8 Hz), 52.9 (q, J = 28.9 Hz); ^{19}F NMR (471 MHz, CD_3OD) δ -71.4; HRMS (EI) m/z calculated for $C_{30}H_{19}F_3N$ $[M - H]^-$: 450.1475, found 450.1483; HPLC: the ee value was determined by HPLC analysis (Chiralpak IG, i-PrOH/hexane = 5/95, 1 mL/min, 215 nm), retention time: t_{minor} = 8.923 min, t_{major}= 10.400 min, ee = 93.2%; $[\alpha]_D^{30}$ = -54.6 (c = 0.99, $CHCl_3$).

Mechanistic studies

1a 14

4-(1,1,1-Trifluoro-4-phenylbut-3-yn-2-ylidene)cyclohexa-2,5-dienone (14)

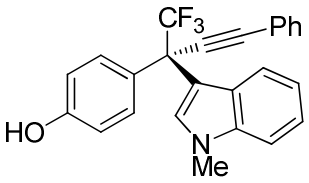
A solution of **1a** (0.1 mmol, 1.0 equiv), MnO_2 (0.5 mmol, 5.0 equiv) and DDQ (0.025 mmol, 0.25 equiv) in CH_2Cl_2 (1.0 mL) was stirred at 60 °C for 8 h. Then it was purified directly by silica gel chromatography using ethyl acetate/petroleum ether 1:9). Yield: 11% (2.9 mg). ^{1}H NMR (500 MHz, C_6D_6) δ 7.37 (dd, *J* = 10.0, 2.6 Hz, 1H), 7.24 – 7.20 (m, 2H), 7.20 – 7.17 (m, 1H), 7.00 – 6.93 (m, 1H), 6.93 – 6.87 (m, *J* = 7.6 Hz, 2H), 6.23 (dd, *J* = 10.0, 1.6 Hz, 1H), 6.08 (dd, *J* = 10.2, 1.9 Hz, 1H); ^{13}C NMR (126 MHz, C_6D_6) δ 185.6, 139.1, 136.1, 132.2, 131.9 (q, *J* = 2.7 Hz), 131.5, 130.6, 130.5, 128.9, 121.9 (q, *J* = 275.7 Hz), 121.5, 121.4 (q, *J* = 34.1 Hz), 110.1, 84.4 (q, *J* = 3.7 Hz); ^{19}F NMR (471 MHz, C_6D_6) δ -55.8; HRMS (ESI) m/z calculated for $C_{16}H_{10}F_3O$ $[M + H]^+$ 275.0678, found 275.0673.



15' 15

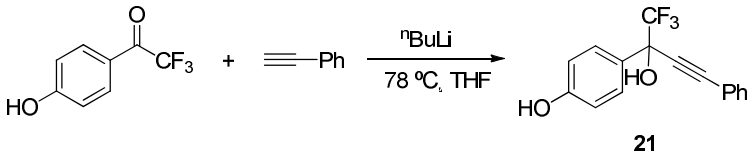
1-Methoxy-4-(1,1,1-trifluoro-4-phenylbut-3-yn-2-yl)benzene (15)

To a solution of **15'** (0.5 mmol, 1.0 equiv) was added Et_3SiH (1.0 mmol, 2.0 equiv) and $BF_3{\cdot}Et_2O$ (0.75 mmol, 1.5 equiv) in CH_2Cl_2 (5.0 mL) at -40 °C. Then it was warmed to room temperature. Upon starting material consumption monitored by TLC, the mixture was quenched by a saturated aqueous $NaHCO_3$ solution. The organic layer was extracted with CH_2Cl_2 and the combined organic layers were washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, filtered and removed under vacuum. The residue was purified by a column chromatography on silica gel using petroleum ether as eluent to give the desired product **15** (68% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 – 7.44 (m, 4H), 7.40 – 7.32 (m, 3H), 6.95 (d, *J* = 8.8 Hz, 2H), 4.53 (q, *J* = 8.0 Hz, 1H), 3.83 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.2, 132.1, 130.7, 129.0, 128.5, 124.6 (q, *J* = 280.4 Hz), 124.1, 122.4, 114.3, 85.7, 82.1 (q, *J* = 3.3 Hz), 55.5, 43.5 (q, *J* = 31.6 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.8; HRMS (ESI) m/z calculated for $C_{17}H_{14}F_3O$ $[M + H]^+$ 291.0991, found 291.0987.



(*S*)-4-(1,1,1-Trifluoro-2-(1-methyl-1*H*-indol-3-yl)-4-phenylbut-3-yn-2-yl)phenol (20)

It was prepared according to the general procedure and purified by a column chromatography on silica gel using CH_2Cl_2. Yield: 60% (24.4 mg) ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.6 Hz, 2H), 7.53 – 7.47 (m, 2H), 7.38 (d, *J* = 8.1 Hz, 1H), 7.35 – 7.29 (m, 4H), 7.27 (m, 1H), 7.25 – 7.20 (m, 1H), 7.05 – 6.98 (m, 1H), 7.04 – 6.99 (m, 1H), 6.77 (d, *J* = 8.8 Hz, 2H), 3.82 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.7, 137.4, 132.1, 130.6, 129.2, 128.8, 128.4, 127.7 (q, *J* = 2.4 Hz), 126.2, 125.8 (q, *J* = 284.3 Hz), 122.7, 122.2, 121.3, 119.6, 115.1, 110.8, 109.5, 86.4, 51.2 (q, *J* = 29.5 Hz), 33.1; ^{19}F NMR (471 MHz, $CDCl_3$) δ -70.5; HRMS (ESI) m/z calculated for $C_{25}H_{17}F_3NO$ $[M - H]^-$ 404.1268, found 404.1275; HPLC: the ee value was determined by HPLC analysis (Chiralpak AD-H, i-PrOH/hexane = 20/80, 1 mL/min, 243 nm), retention time: t_{minor} = 4.707 min, t_{major}= 6.463 min, ee = 5.1%.



21

4-(1,1,1-Trifluoro-2-hydroxy-4-phenylbut-3-yn-2-yl)phenol (21)

To a solution of alkyne (2 mmol, 2.0 equiv) in anhydrous THF at -78 °C under N_2 was added ^{n}BuLi (2 mmol, 0.8 mL, 2.5 M in hexane, 2.0 equiv) dropwise. The reaction was stirred at the same temperature for 1 h. Then a solution of ketone (1 mmol, 1.0 equiv) in anhydrous THF (5 mL) was added to the mixture dropwise. The reaction was kepted at -78°C for 15 min and then warmed up to room temperature slowly overnight. Upon completion, the mixture was quenched by a saturated aqueous NH_4Cl solution. The organic layer was extracted with ethyl acetate and the combined organic layers were washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, filtered and removed under vacuum. The residue was purified by a column chromatography on silica gel using ethyl acetate/petroleum ether as eluent to give the desired product **21** (70% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.6 Hz, 2H), 7.54 – 7.51 (m, 2H), 7.43 – 7.33 (m, 3H), 6.88 (d, *J* =

8.8 Hz, 2H), 5.66 (brs, 1H), 3.50 (brs, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.6, 132.2, 129.7, 129.1, 128.7, 127.8, 123.6 (q, J = 285.5 Hz), 121.1, 115.4, 88.3, 84.6, 73.4 (q, J = 32.6 Hz); HRMS (ESI) m/z calculated for $C_{16}H_{10}F_3O_2$ $[M - H]^-$ 291.0638, found 291.0645.

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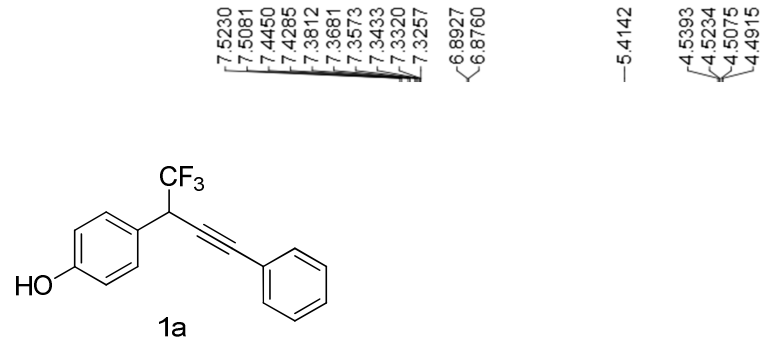
NMR spectra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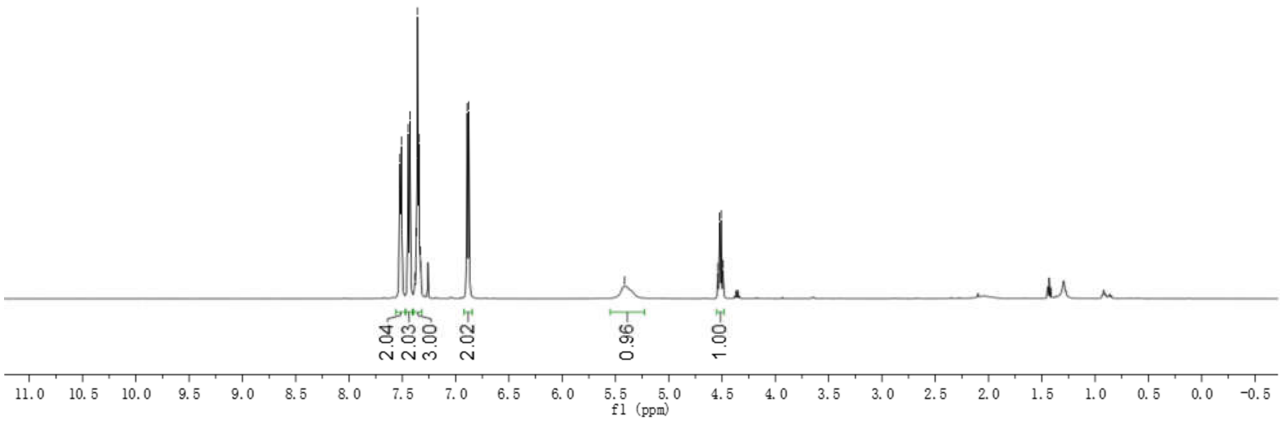
1a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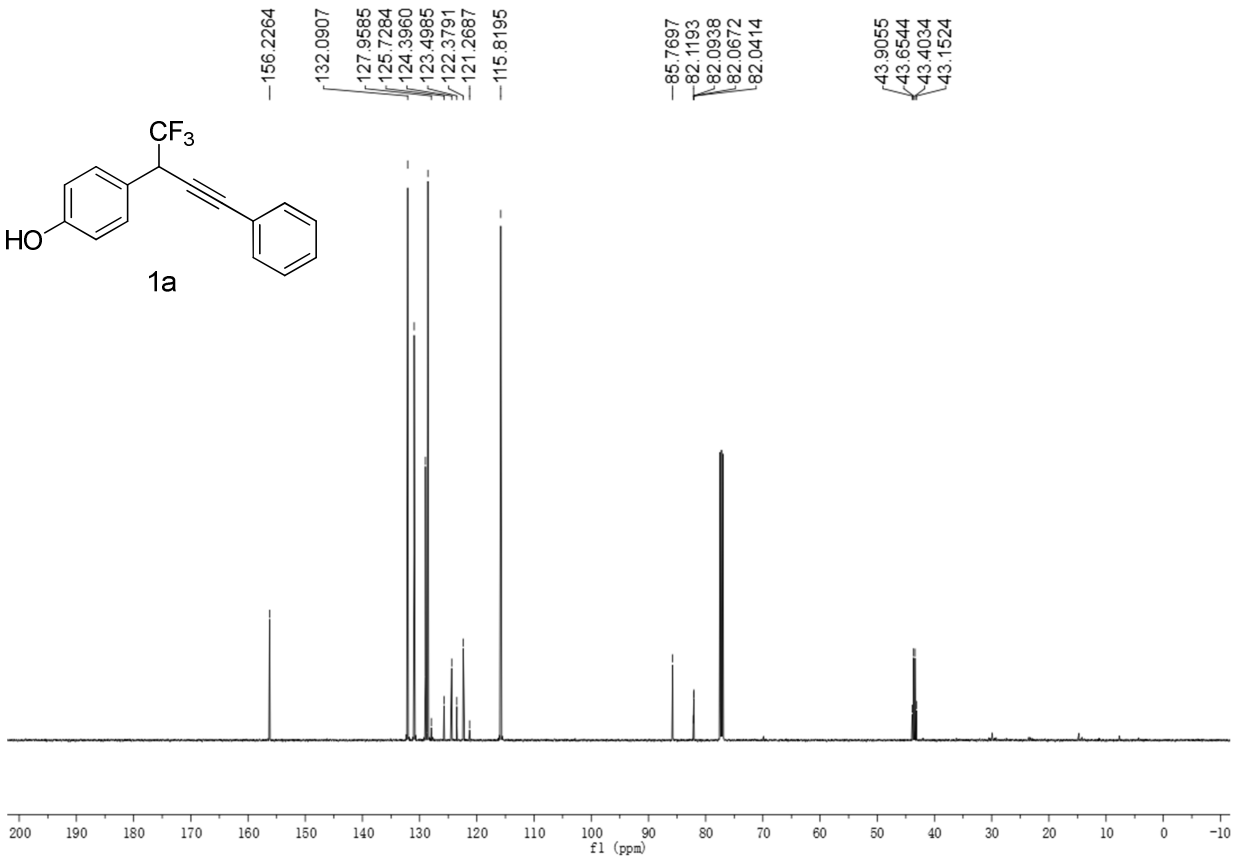
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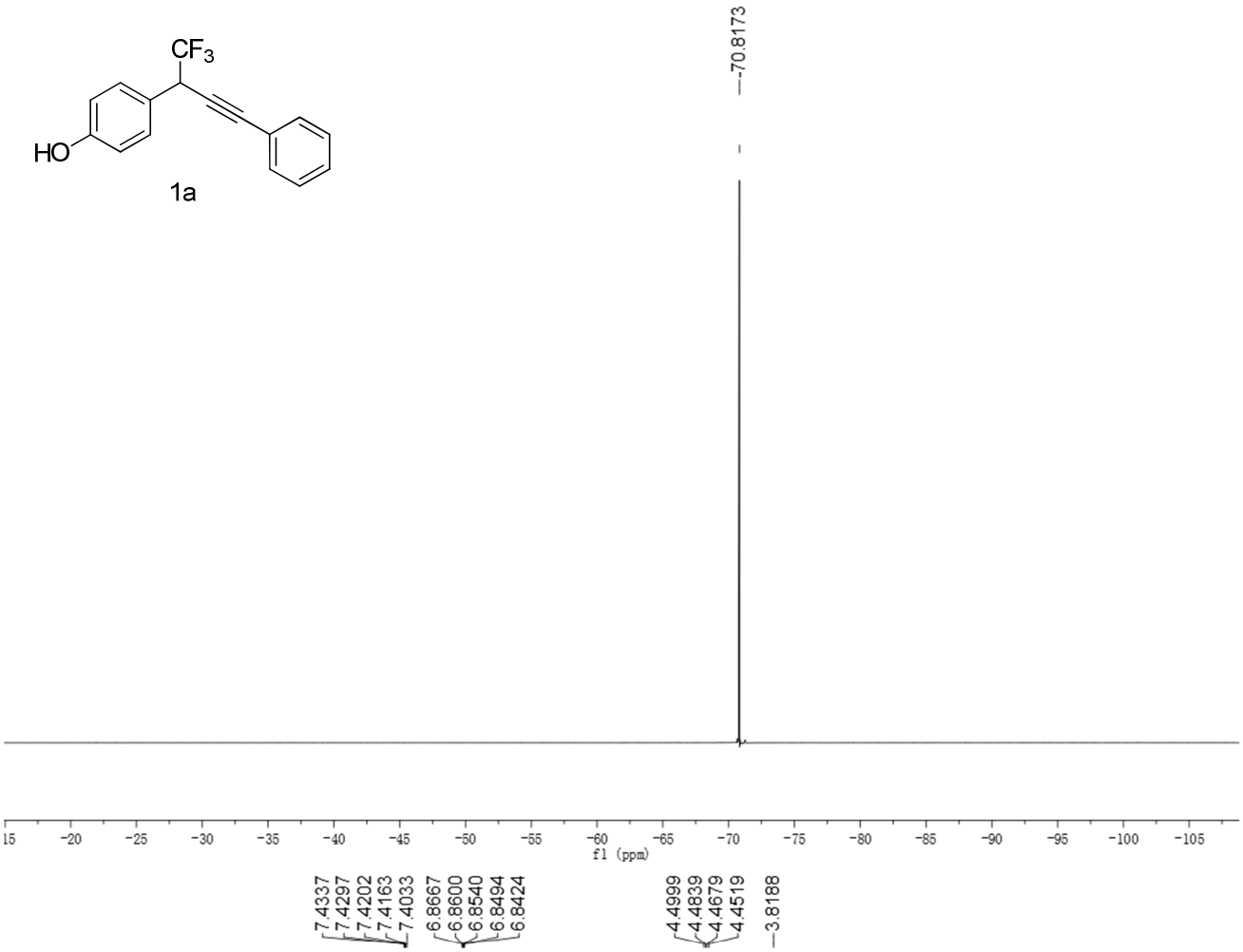
CF3
HO

1a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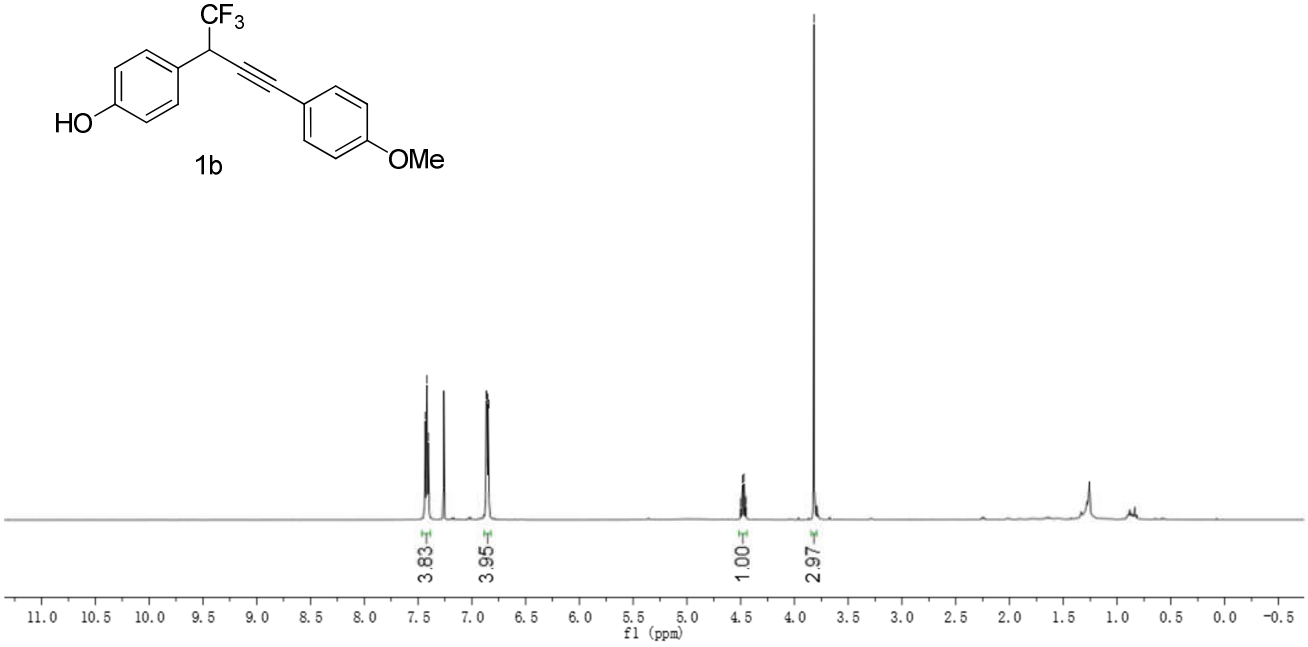
1b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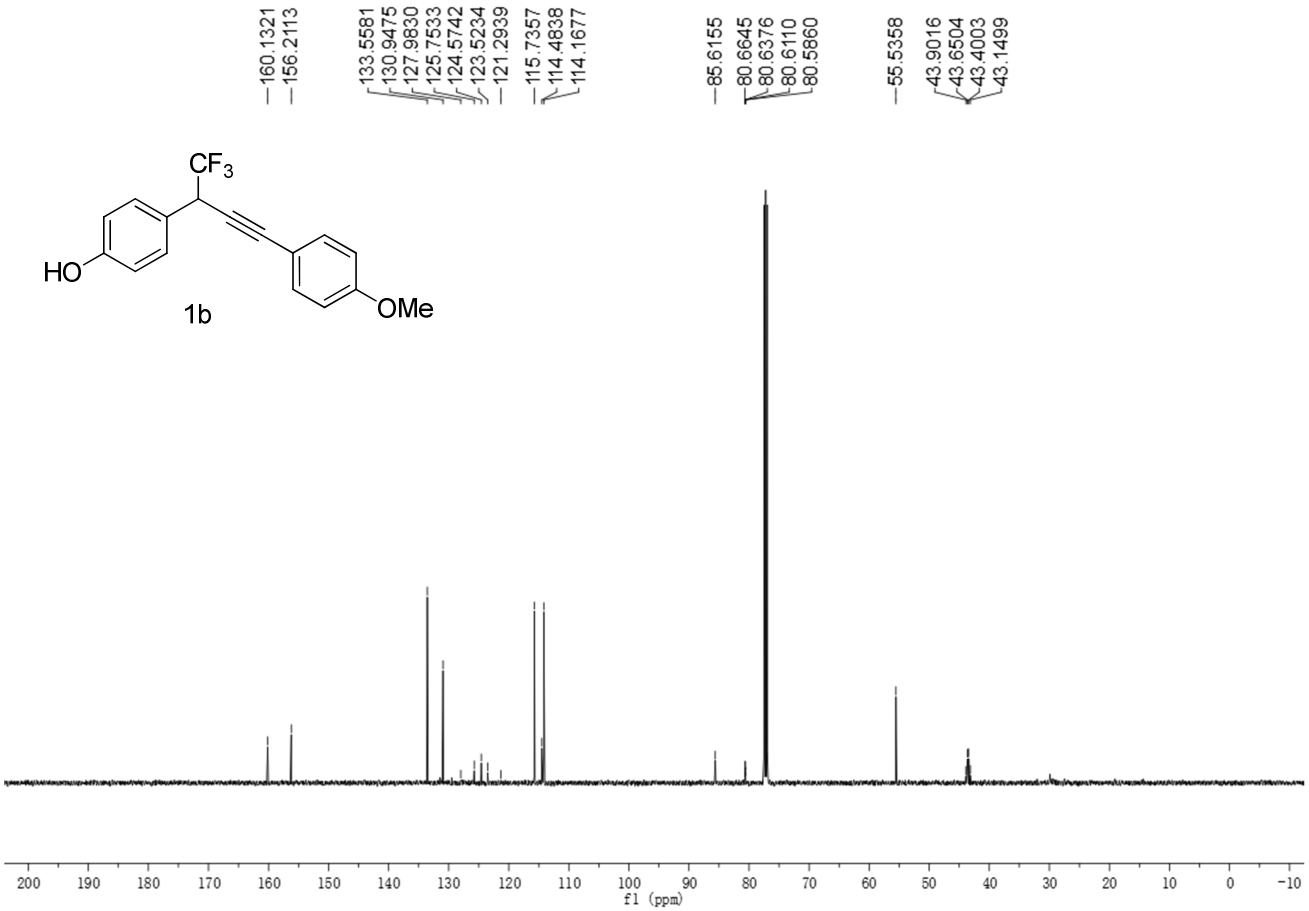
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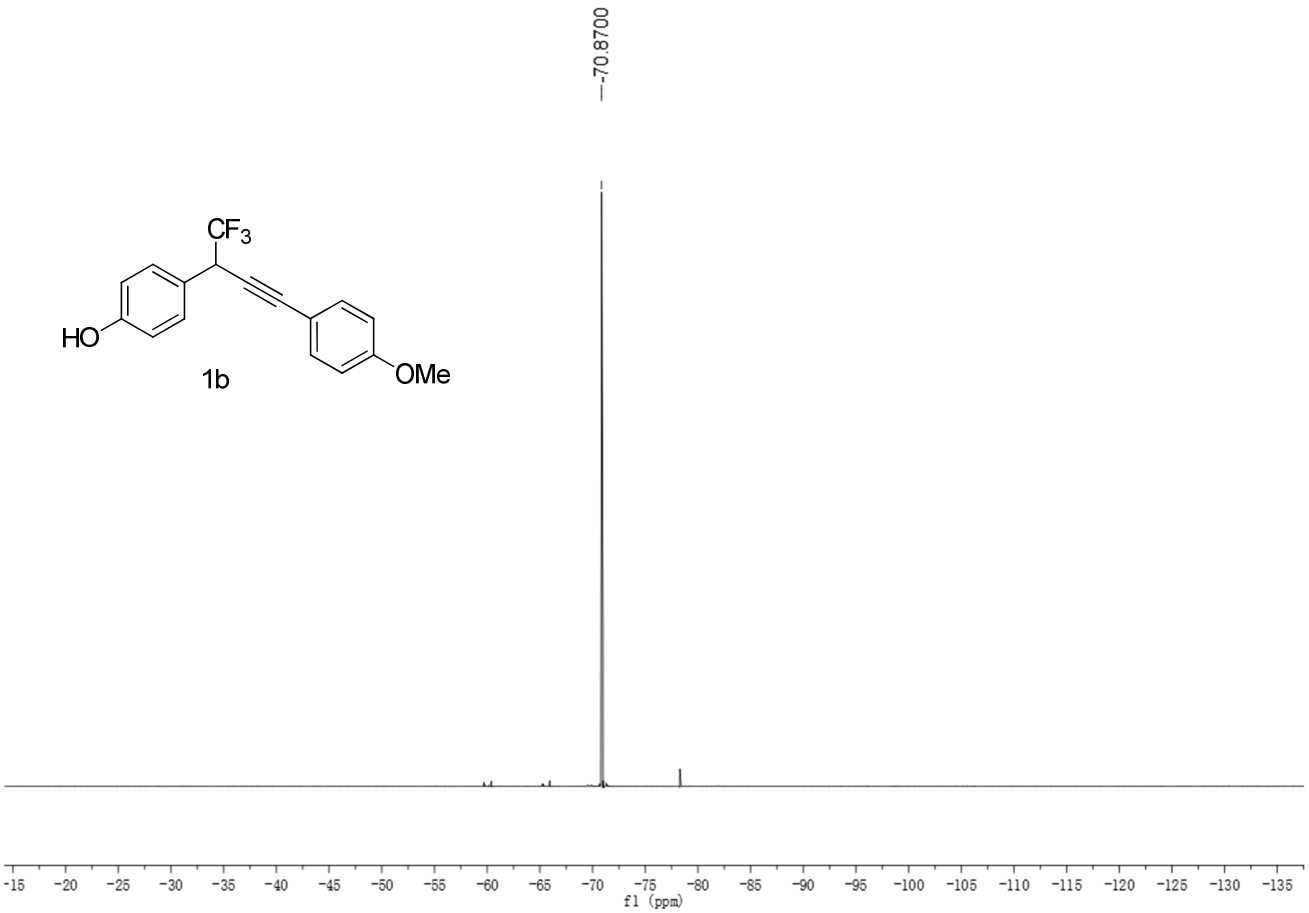
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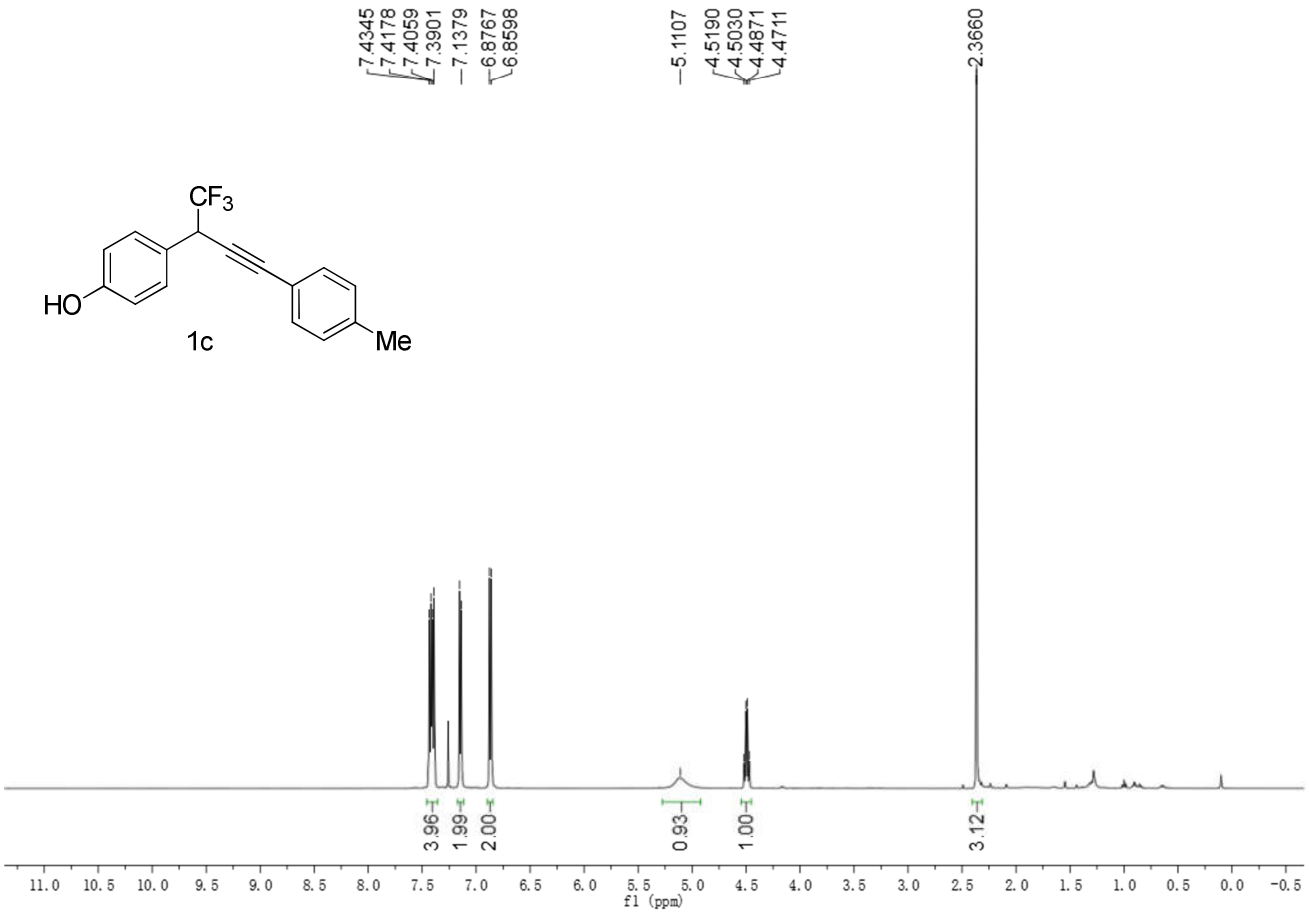
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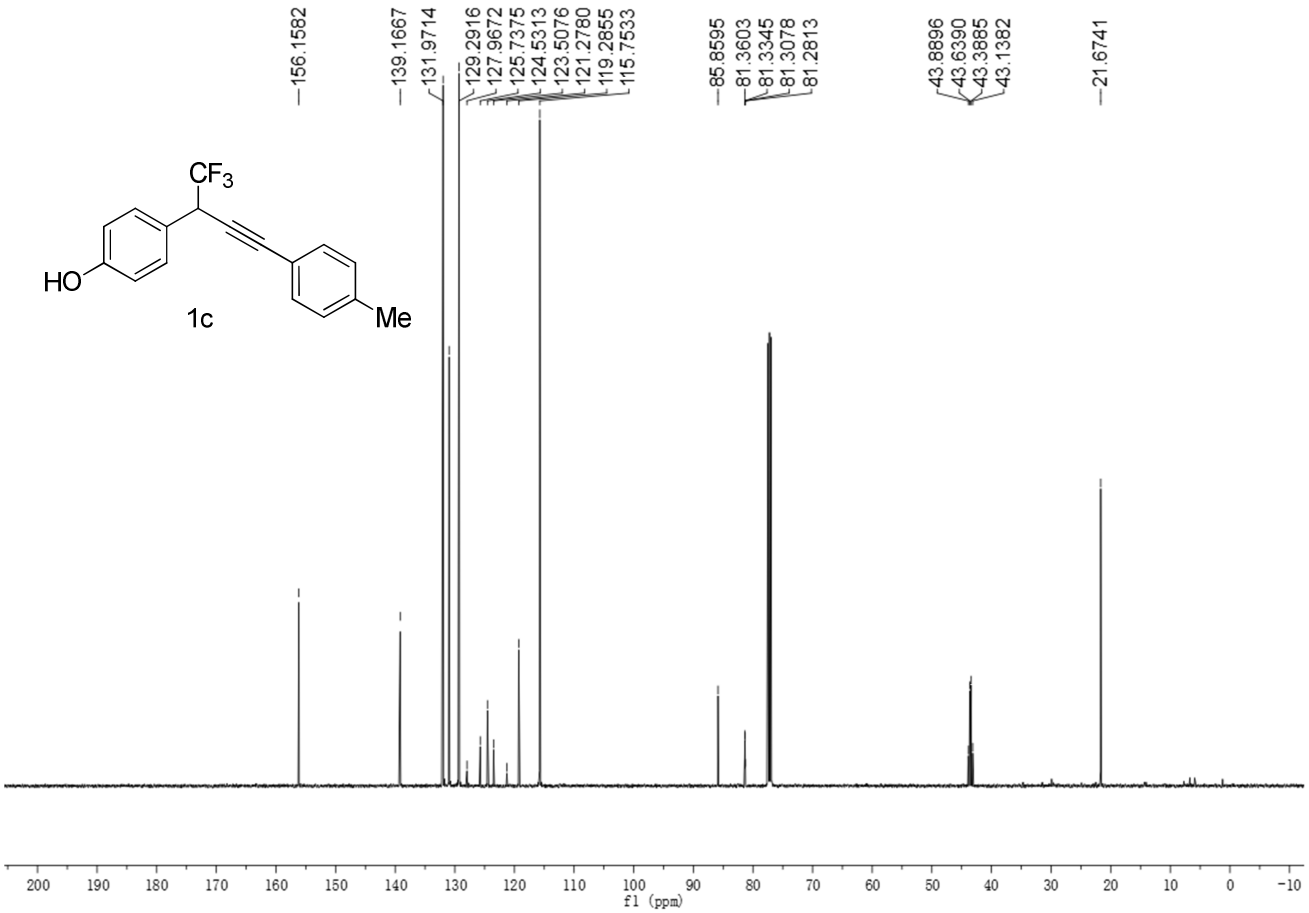
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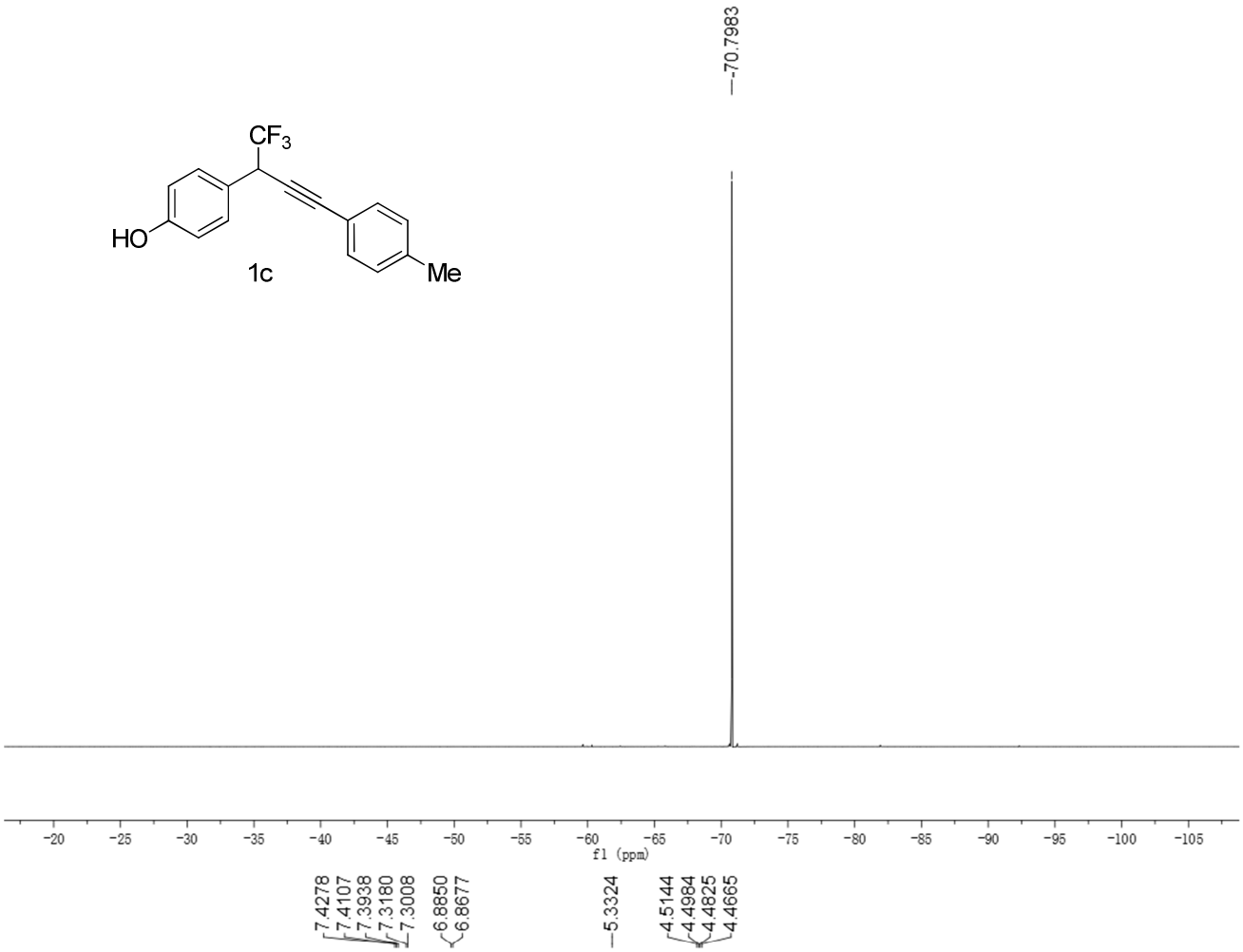
1c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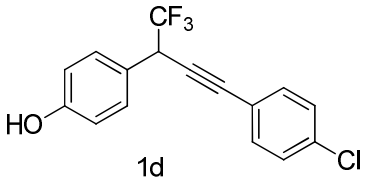
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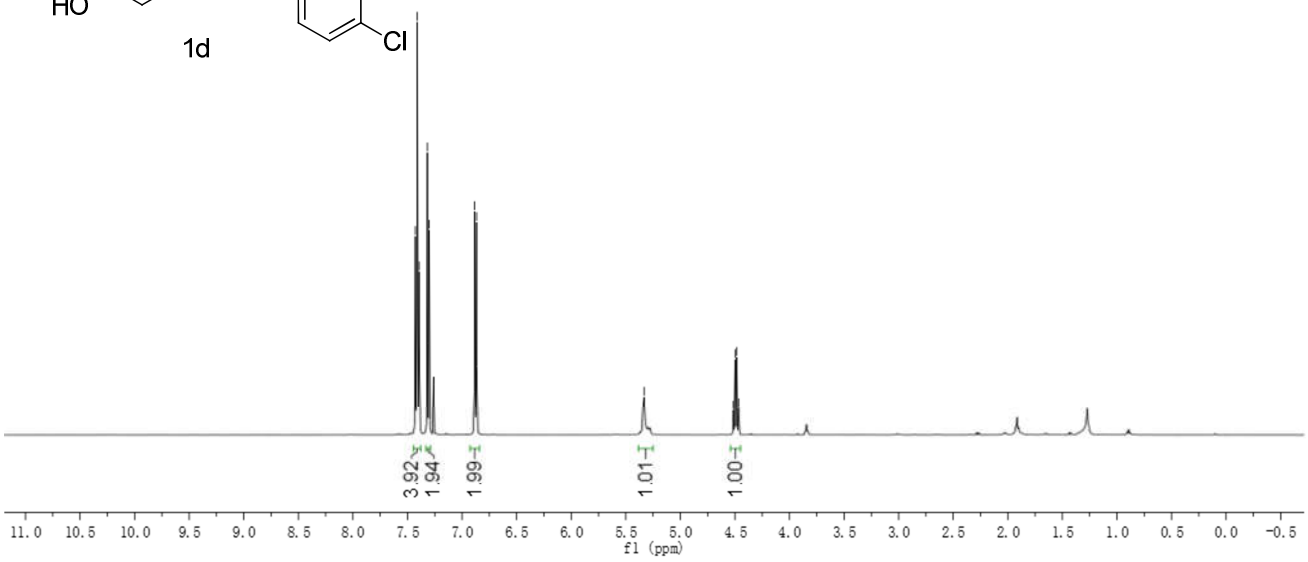
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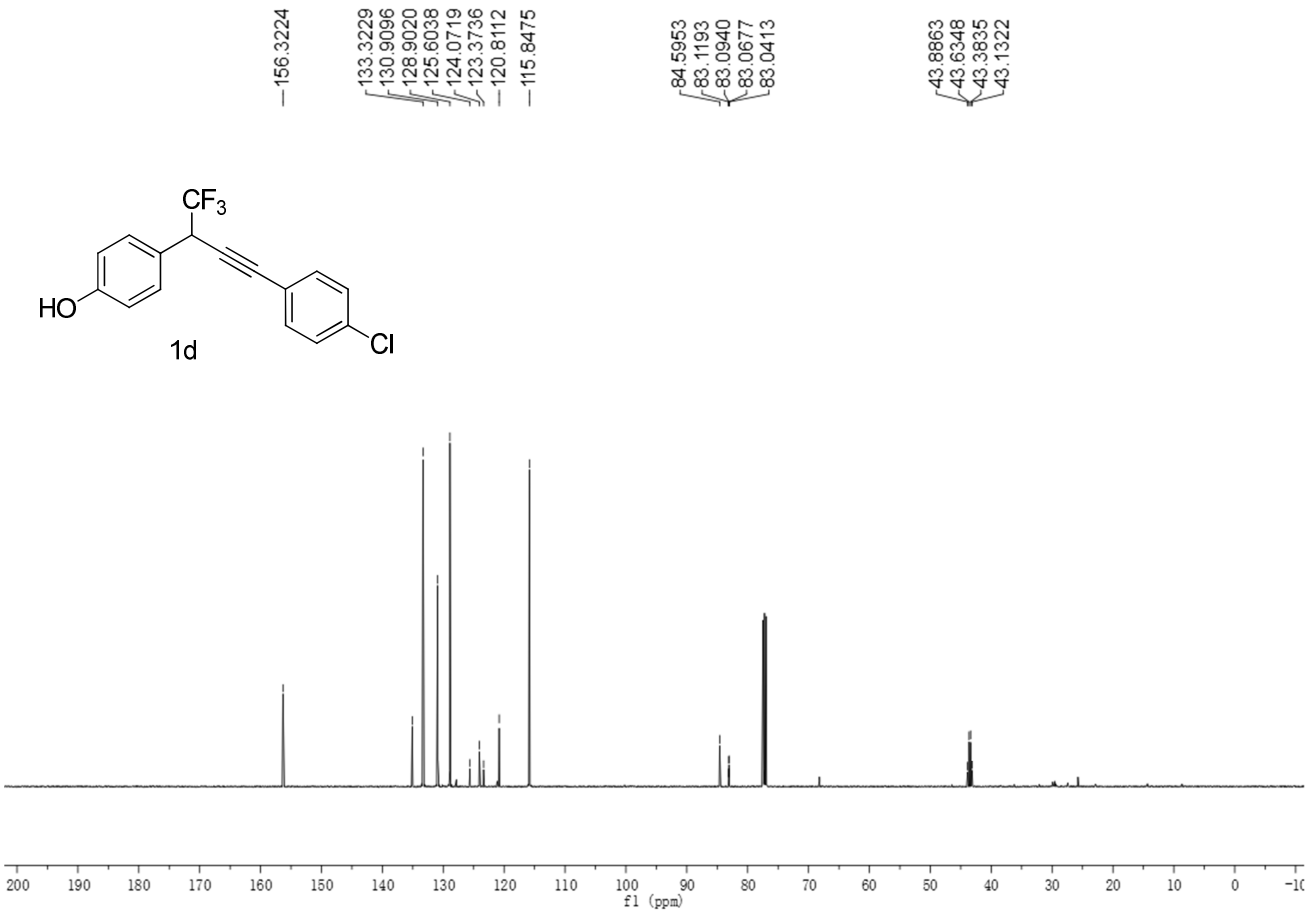
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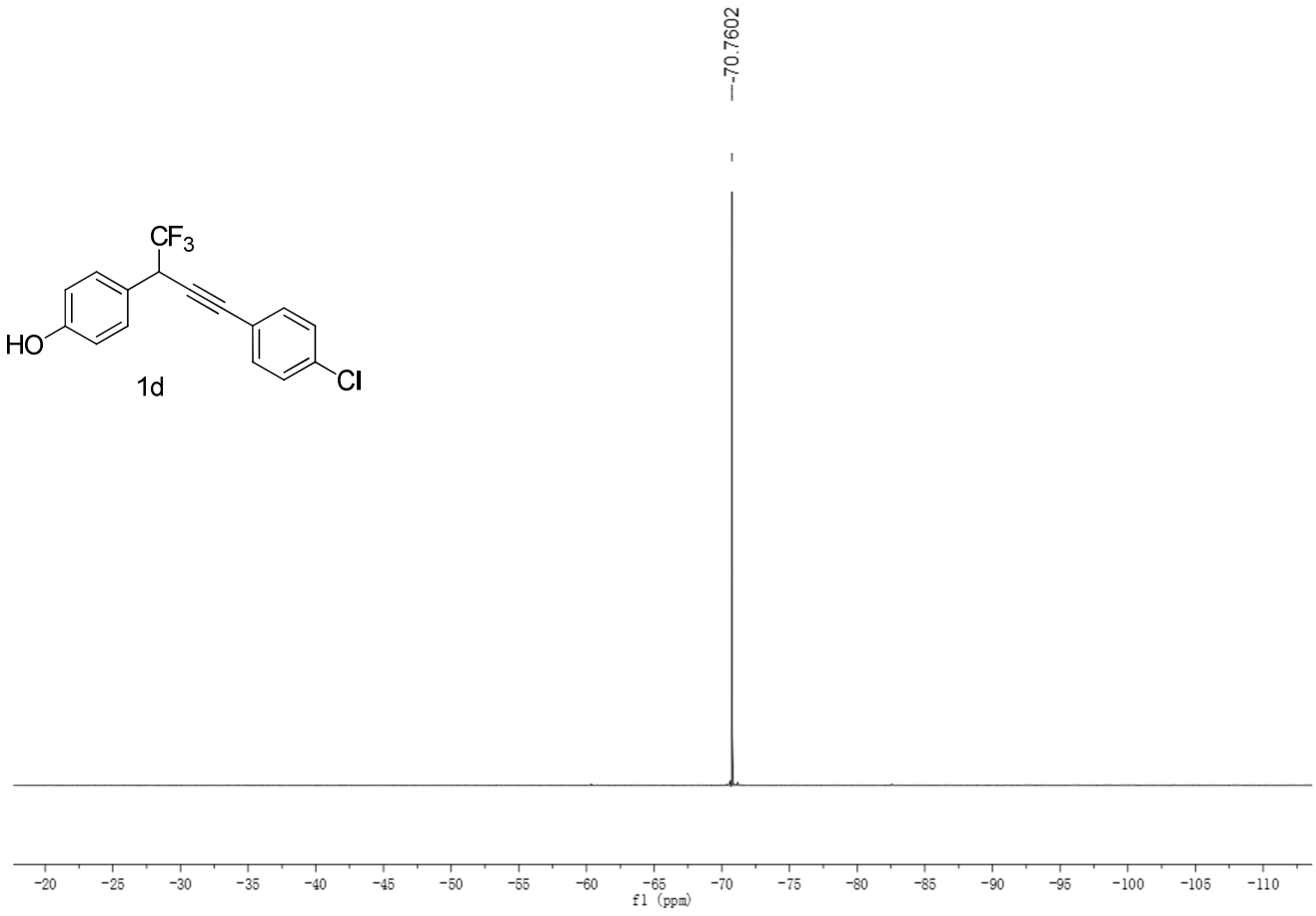
43.1322
CF3
HO
Cl
1d
f1 (ppm)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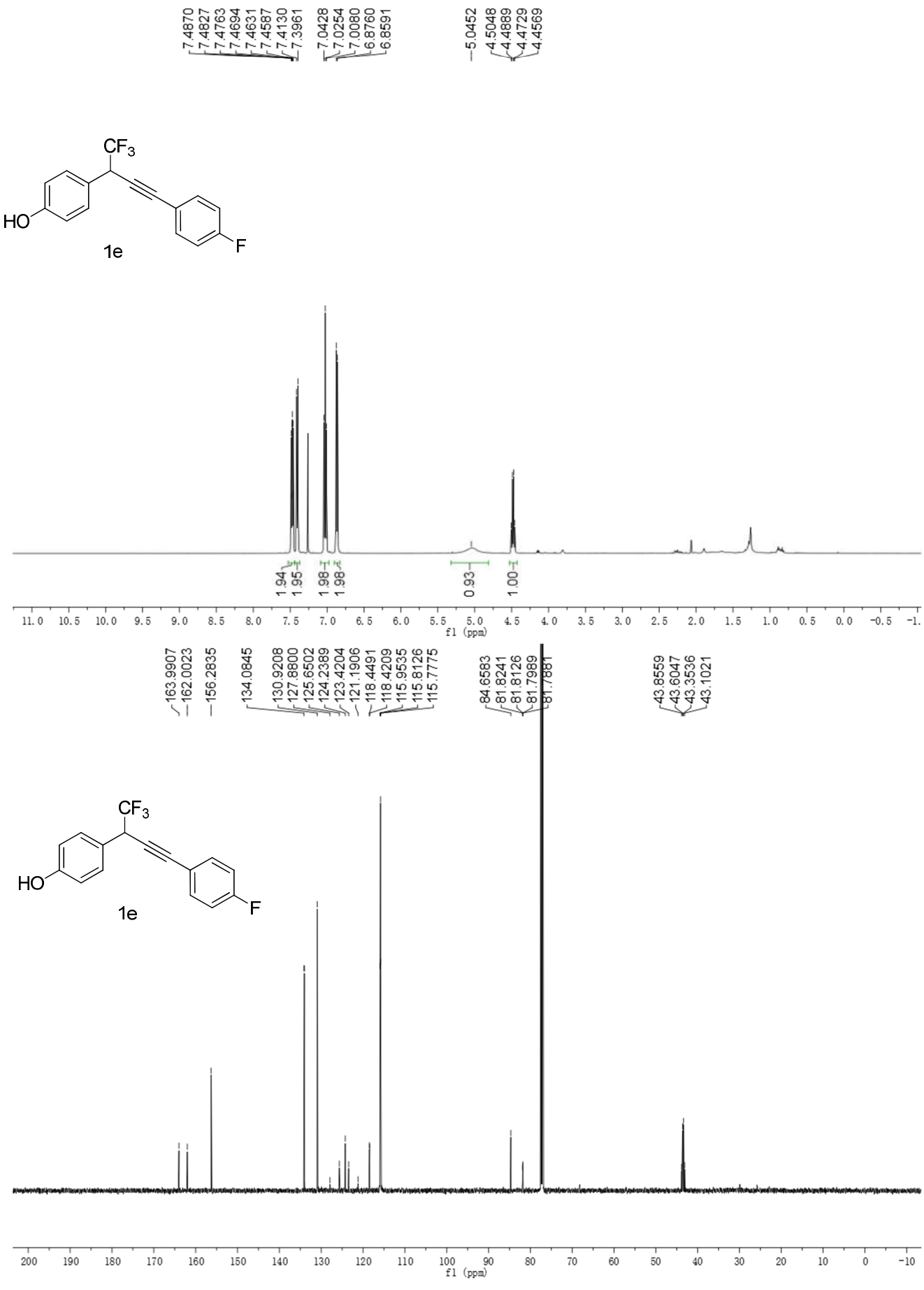
HO
Cl
1d
f1 (ppm)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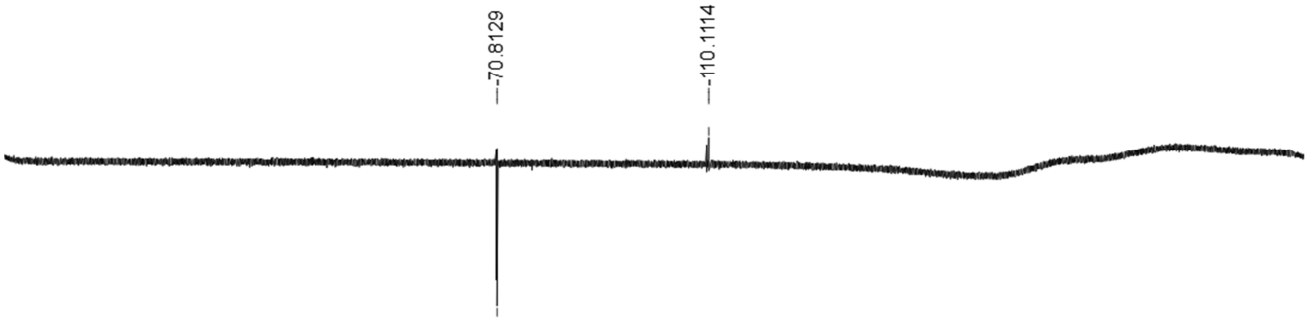
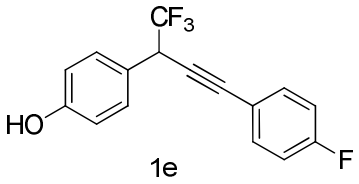
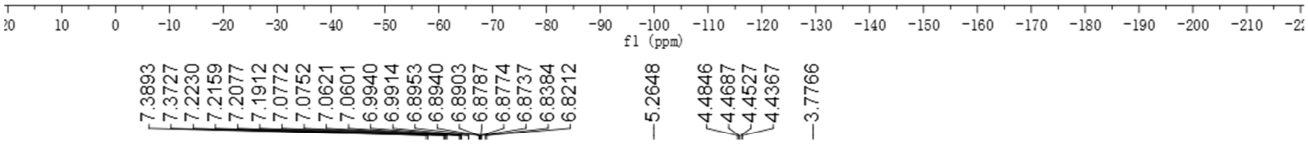
7.4827
7.4763
7.4694
7.4631
7.4587
7.4130
7.3961
7.0428
7.0254
7.0080
6.8760
6.8591
5.0452
4.5048
4.4889
4.4729
4.4569
CF3
HO
F
1e
1.94
1.95
1.98
1.98
0.93
1.00
f1 (ppm)
163.9907
162.0023
156.2835
134.0845
130.9208
127.8800
125.6502
124.2389
123.4204
121.1906
118.4491
118.4209
115.9535
115.8126
115.7775
84.6583
81.8241
81.8126
81.7989
81.7881
43.8559
43.6047
43.3536
43.1021
CF3
HO
F
1e
f1 (ppm)


-70.8129
-110.1114


CF3
HO
F

1e


f1 (ppm)
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7.3727
7.2230
7.2159
7.2077
7.1912
7.0772
7.0752
7.0621
7.0601
6.9940
6.9914
6.8953
6.8940
6.8903
6.8787
6.8774
6.8737
6.8384
6.8212
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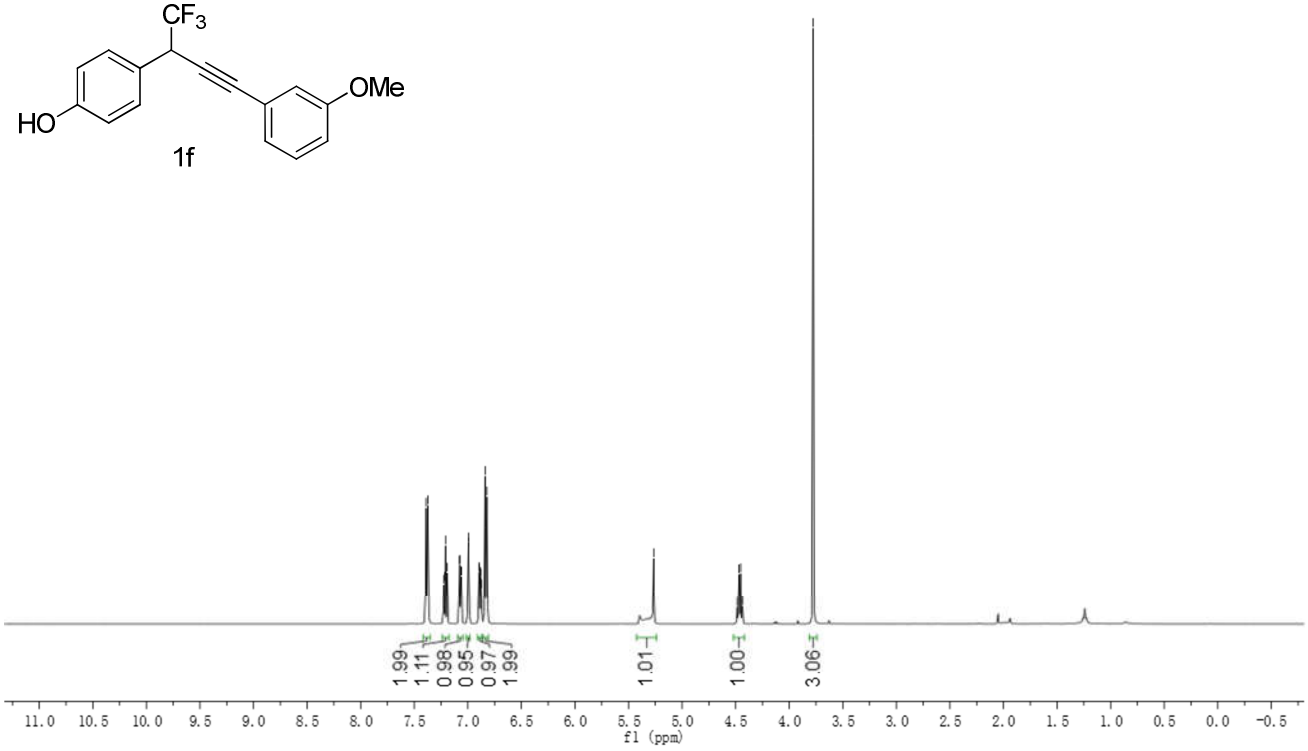
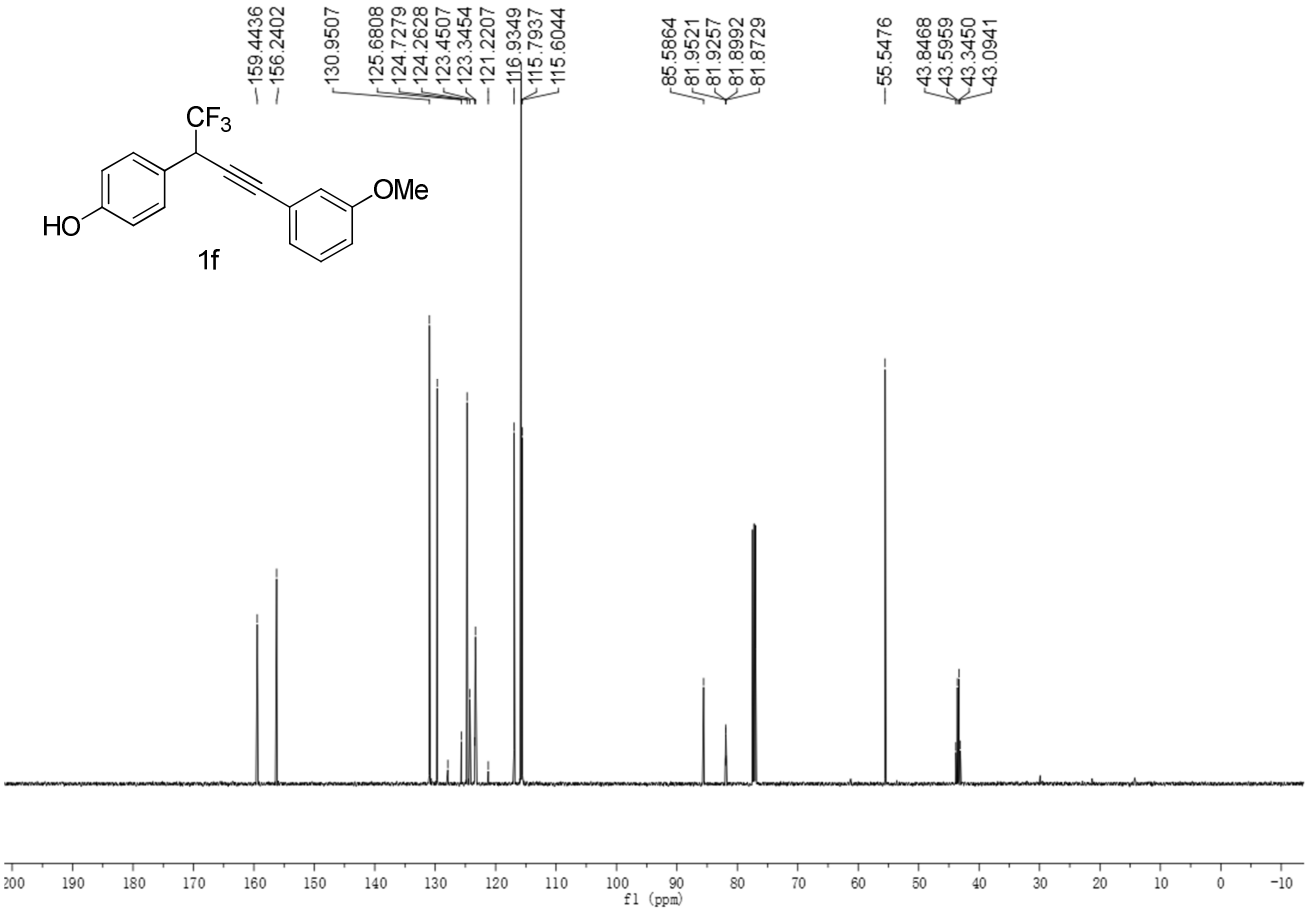
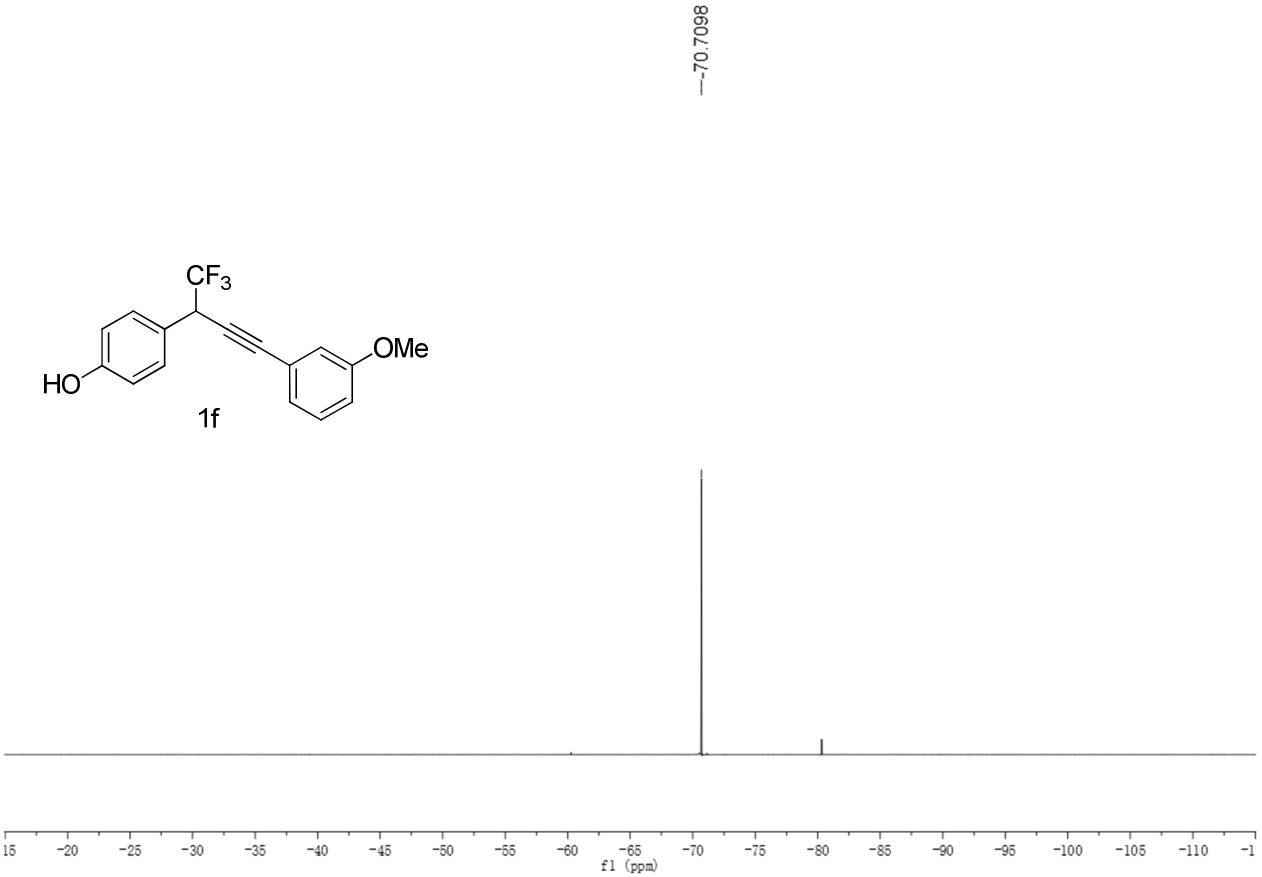
4.4846
4.4687
4.4527
4.4367
3.7766

CF3
HO
OMe

1f


1.99
1.11
0.98
0.95
0.97
1.99
1.01
1.00
3.06
f1 (ppm)


159.4436
156.2402
130.9507
125.6808
124.7279
124.2628
123.4507
123.3454
121.2207
116.9349
115.7937
115.6044
85.5864
81.9521
81.9257
81.8992
81.8729
55.5476
43.8468
43.5959
43.3450
43.0941
CF3
OMe
HO
1f
f1 (ppm)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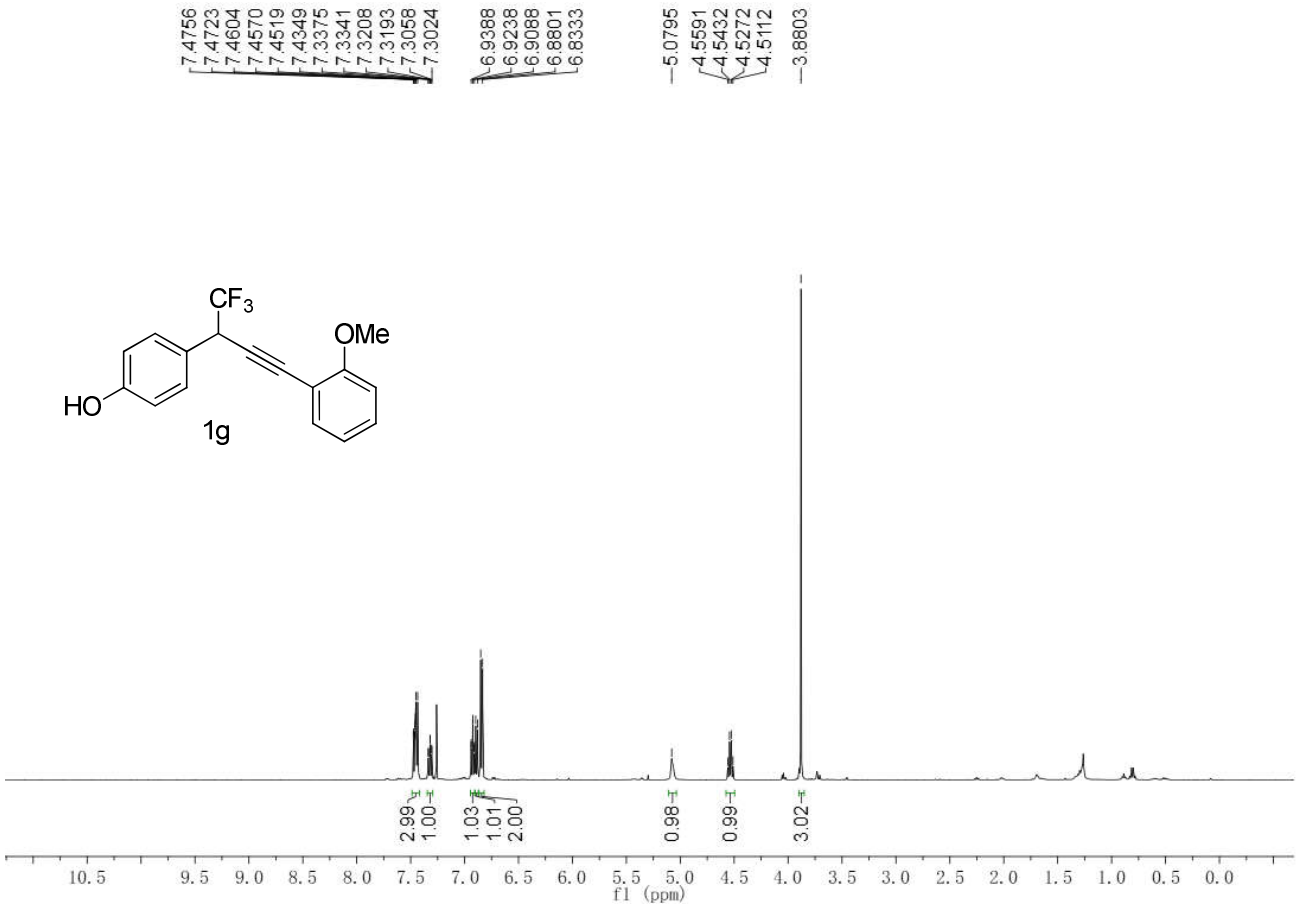
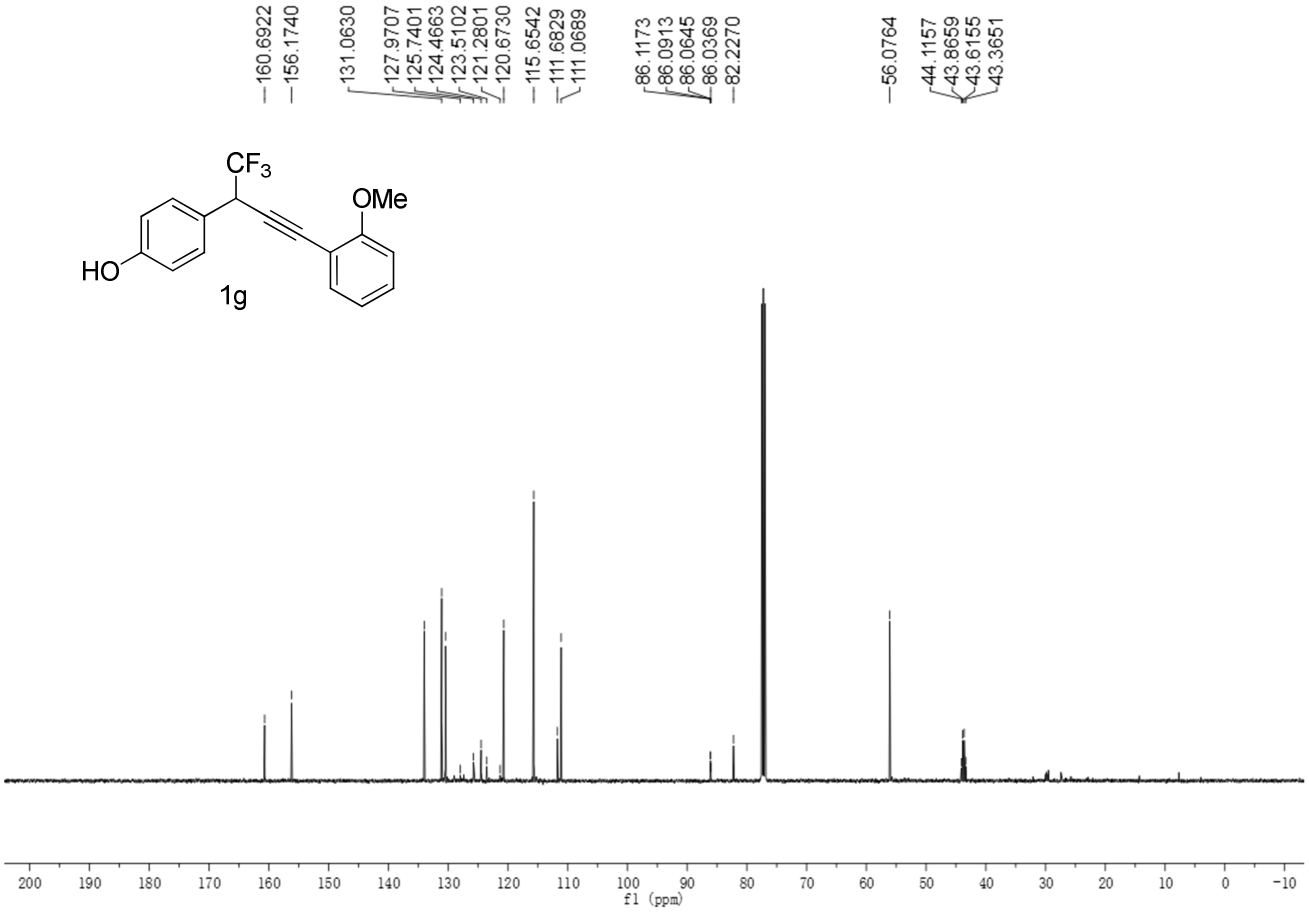
OMe
HO
1f
f1 (ppm)


7.4756
7.4723
7.4604
7.4570
7.4519
7.4349
7.3375
7.3341
7.3208
7.3193
7.3058
7.3024
6.9388
6.9238
6.9088
6.8801
6.8333
5.0795
4.5591
4.5432
4.5272
4.5112
3.8803
CF3
OMe
HO
1g
2.99
1.00
1.03
1.01
2.00
0.98
0.99
3.02
f1 (ppm)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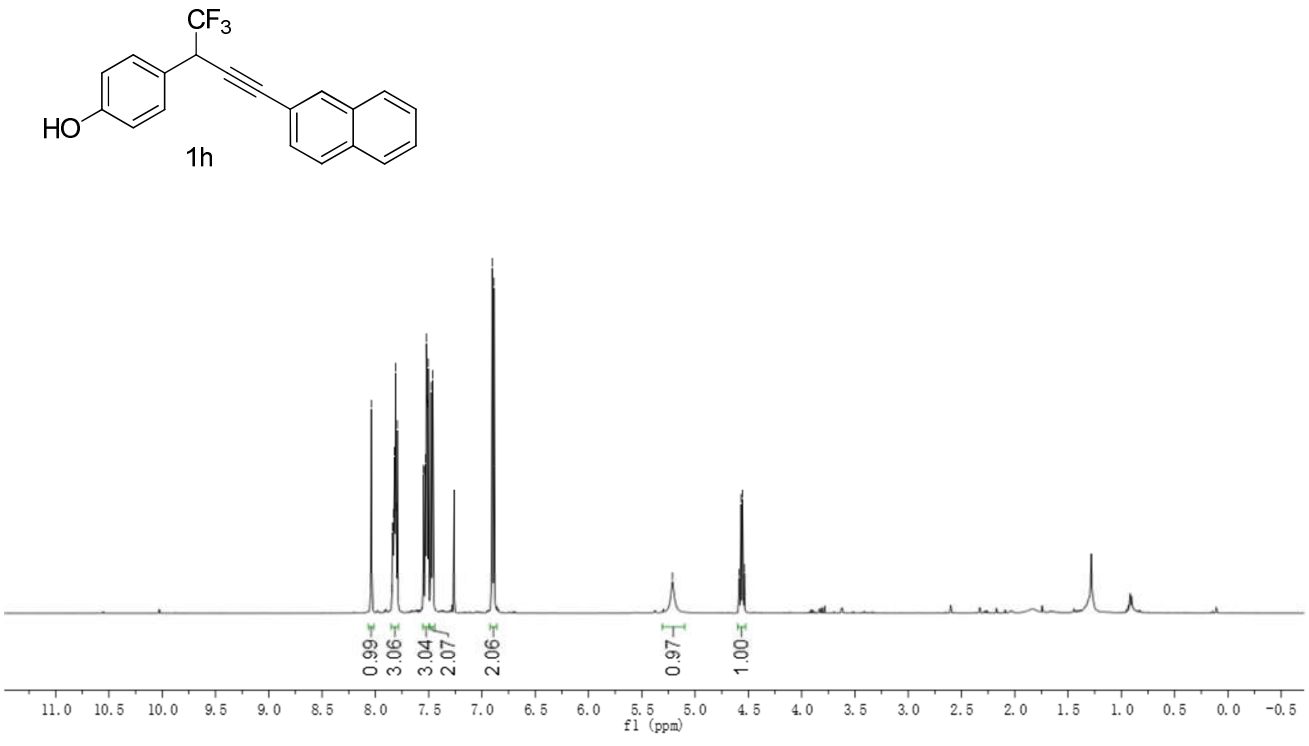
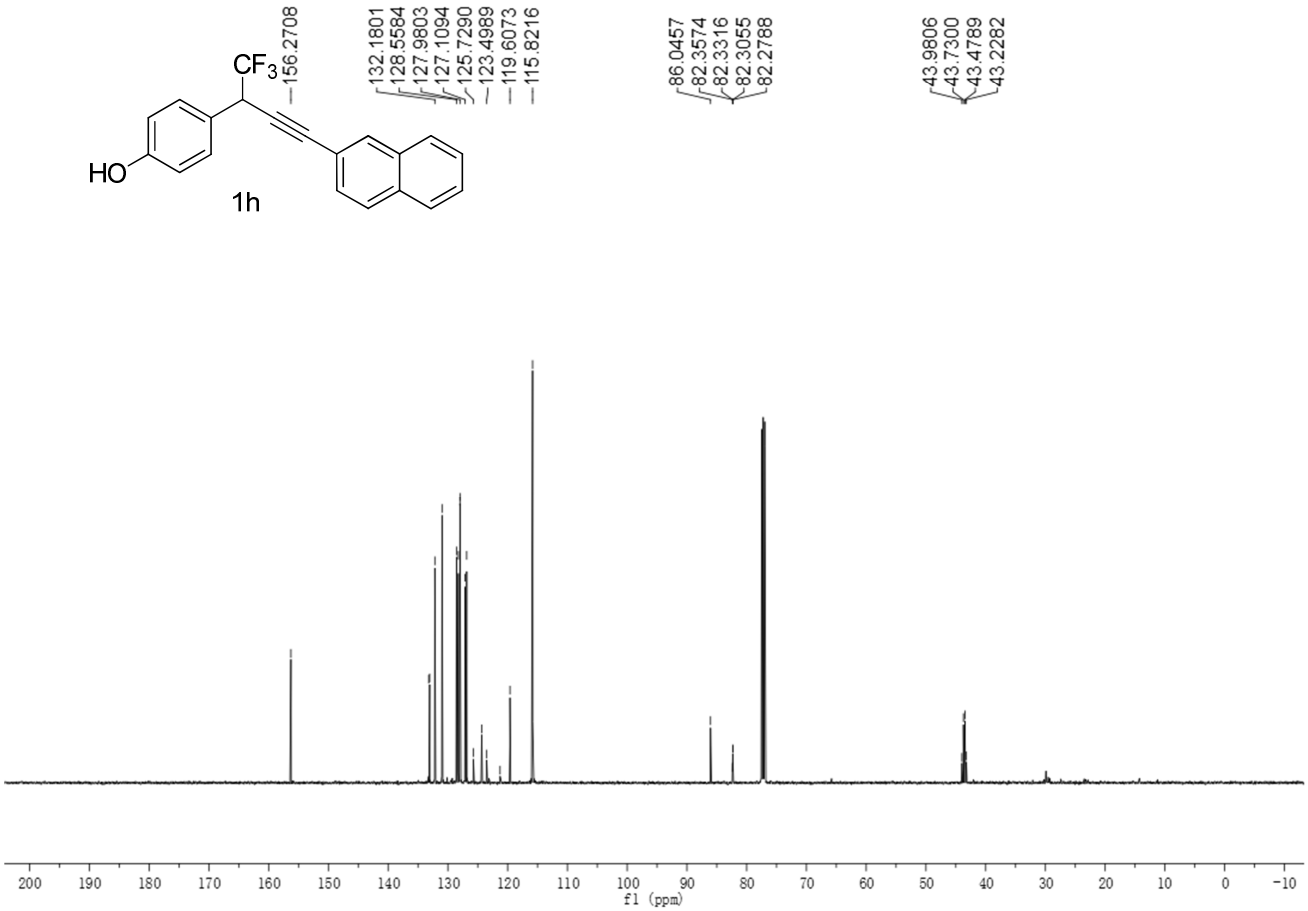
156.1740
131.0630
127.9707
125.7401
124.4663
123.5102
121.2801
120.6730
115.6542
111.6829
111.0689
86.1173
86.0913
86.0645
86.0369
82.2270
56.0764
44.1157
43.8659
43.6155
43.3651
CF3
OMe
HO
1g
f1 (ppm)


-70.7629
CF3
OMe
HO
1g
f1 (ppm)
8.0380
7.8455
7.8386
7.8315
7.8273
7.8205
7.8098
7.8025
7.7936
7.5218
7.4610
6.9036
6.8863
5.2123
4.5858
4.5699
4.5539
4.5379


CF3
HO
1h
0.99
3.06
3.04
2.07
2.06
0.97
1.00
f1 (ppm)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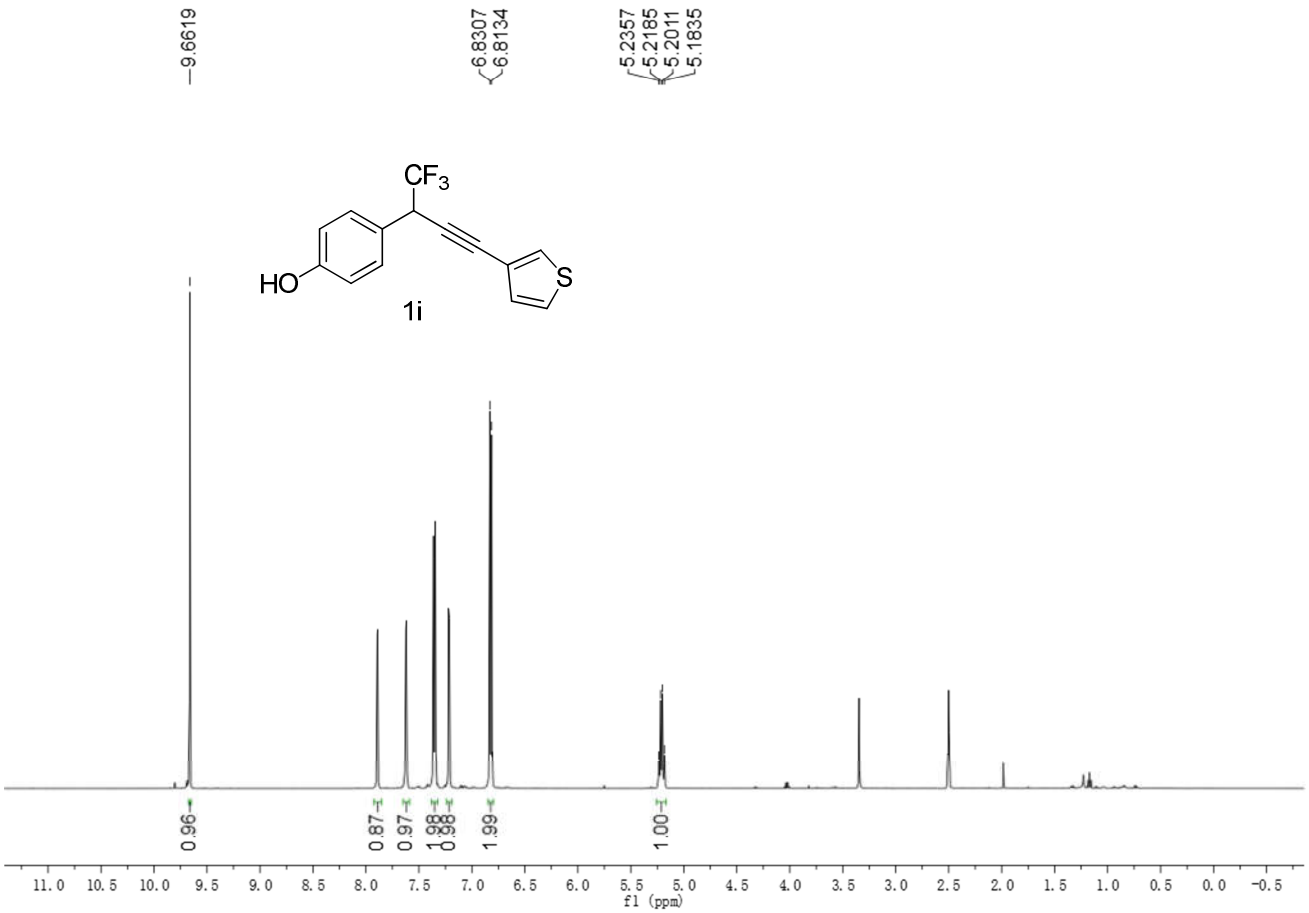
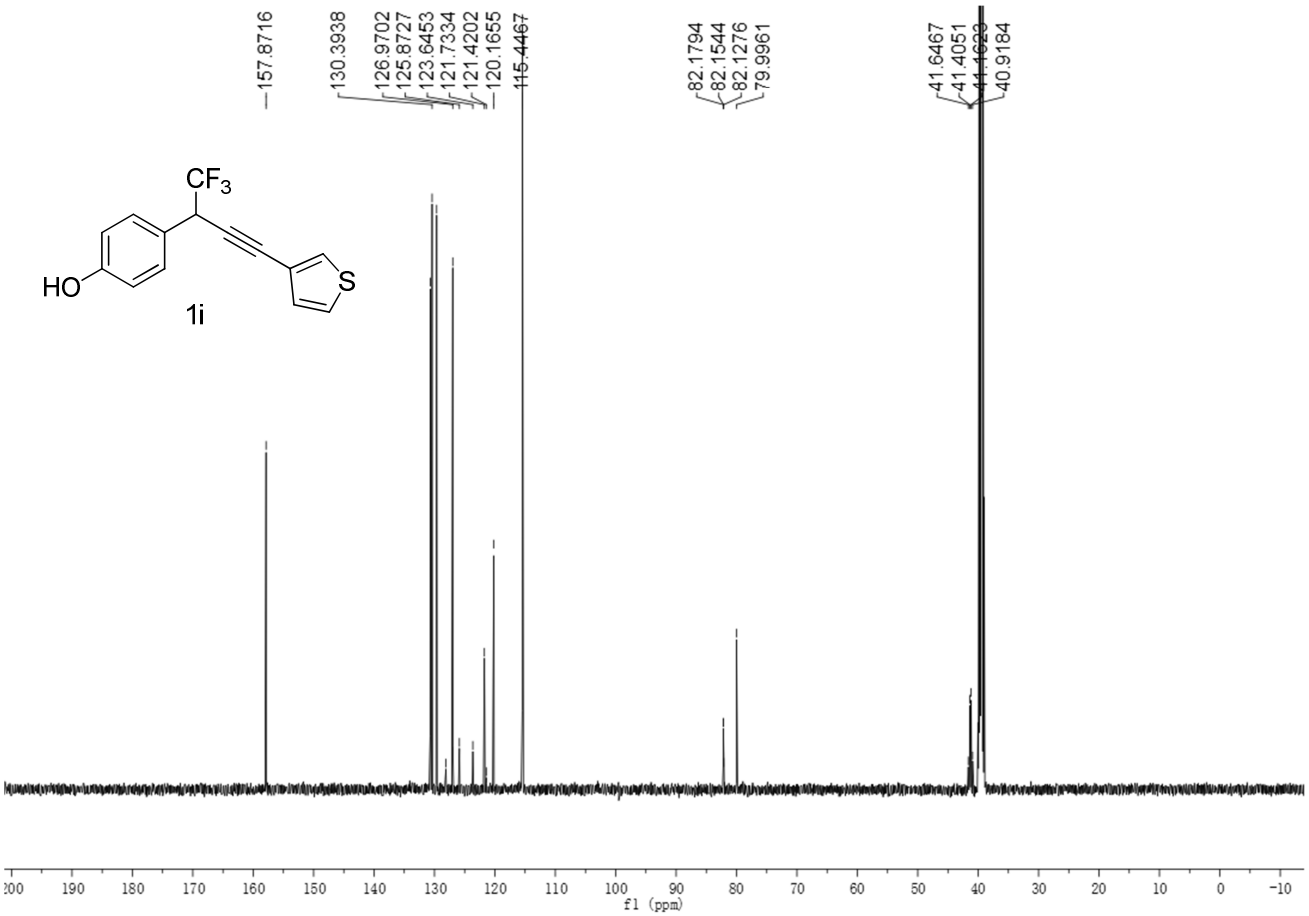
128.5584
127.9803
127.1094
125.7290
123.4989
119.6073
115.8216
86.0457
82.3574
82.3316
82.3055
82.2788
43.9806
43.7300
43.4789
43.2282
CF3
HO
1h
f1 (ppm)


-70.7372
CF3
HO
1h
f1 (ppm)


9.6619
6.8307
6.8134
5.2357
5.2185
5.2011
5.1835
CF3
HO
S
1i
0.96
0.87
0.97
1.98
0.88
1.99
1.00
f1 (ppm)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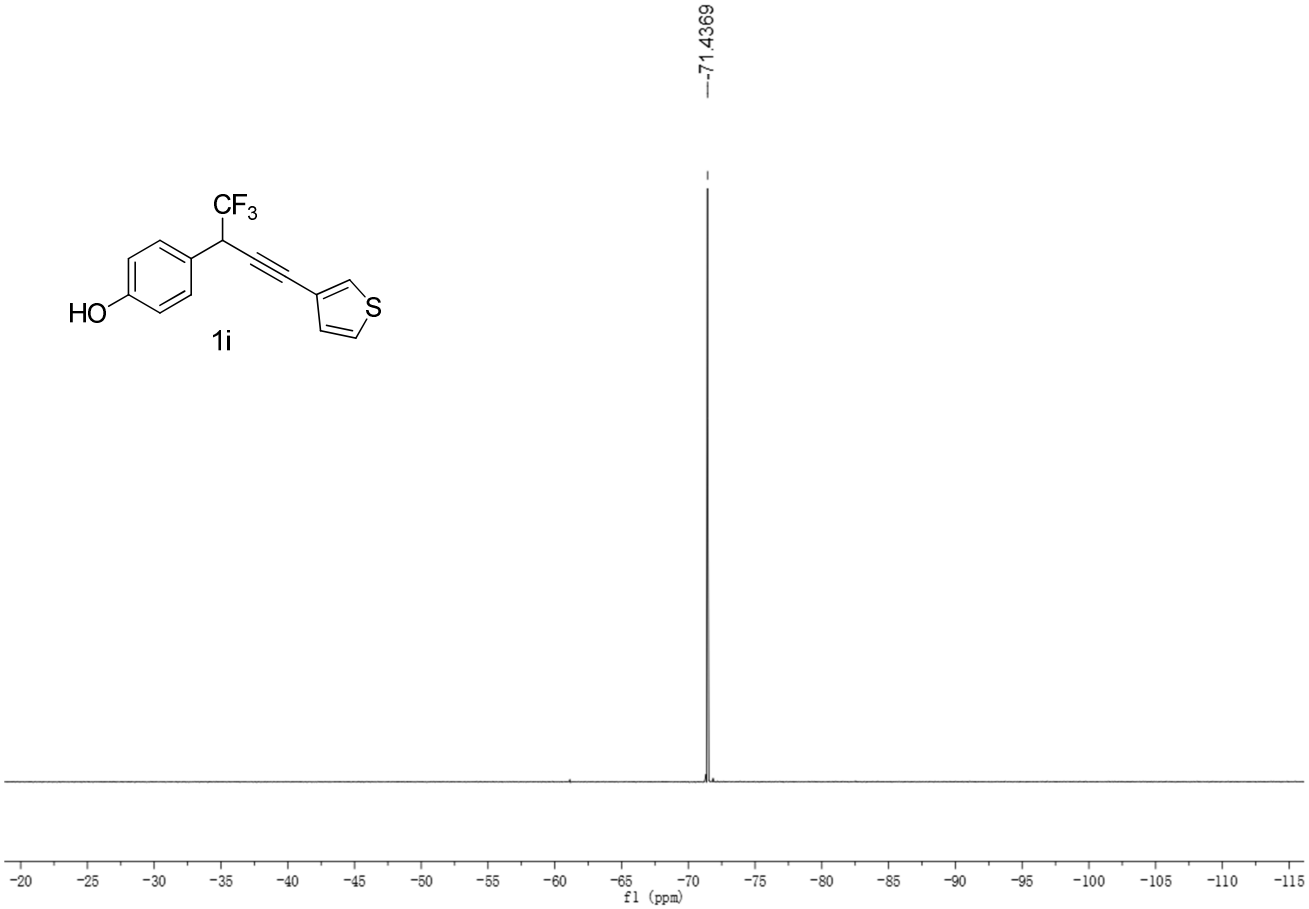
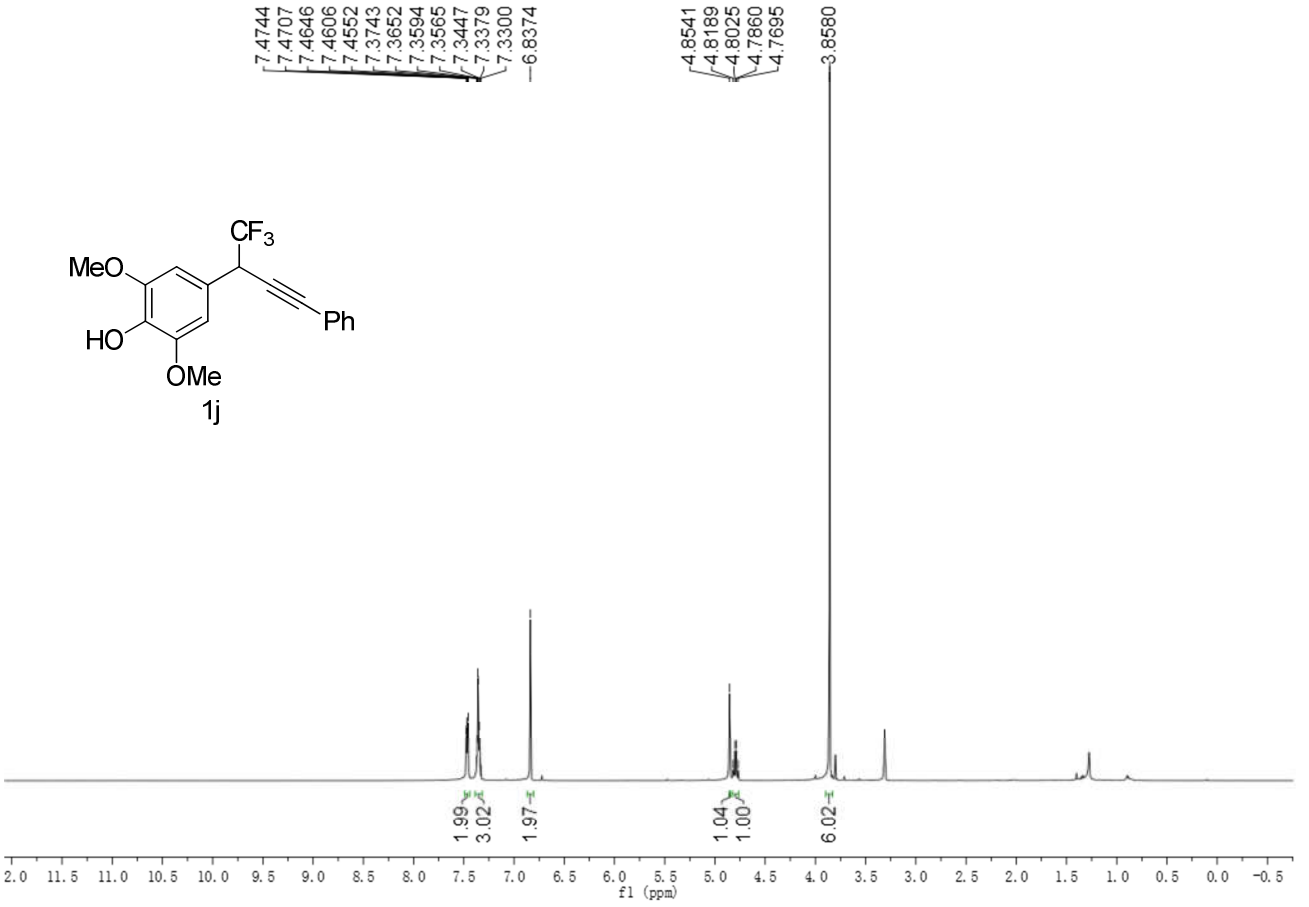
130.3938
126.9702
125.8727
123.6453
121.7334
121.4202
120.1655
115.4467
82.1794
82.1544
82.1276
79.9961
41.6467
41.4051
40.9184
CF3
HO
S
1i
f1 (ppm)


-71.4369
CF3
HO
S
1i
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)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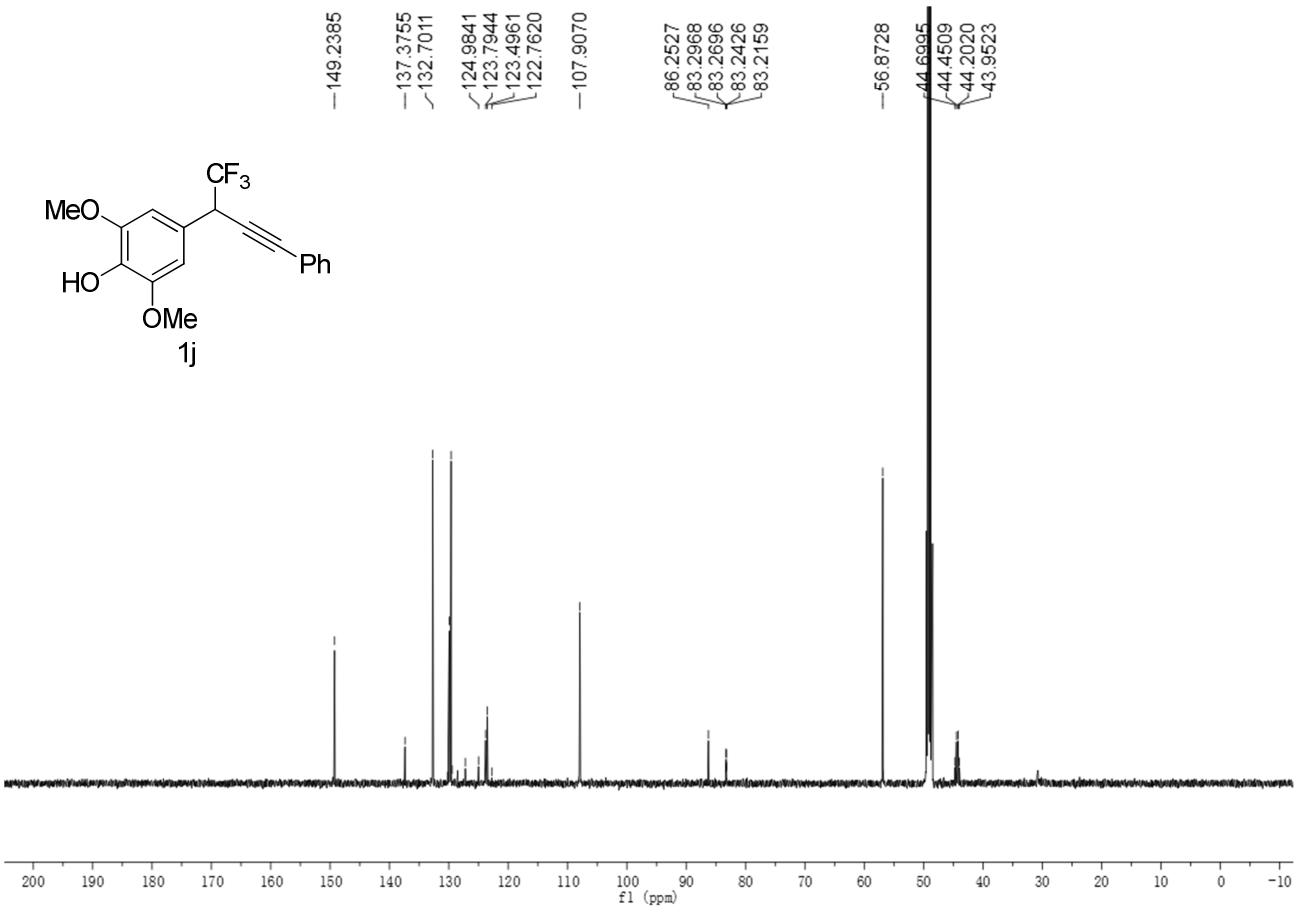
7.4707
7.4646
7.4606
7.4552
7.3743
7.3652
7.3594
7.3565
7.3447
7.3379
7.3300
6.8374
4.8541
4.8189
4.8025
4.7860
4.7695
3.8580
CF3
MeO
HO
OMe
Ph
1j
1.99
3.02
1.97
1.04
1.00
6.02
2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


149.2385
137.3755
132.7011
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123.7944
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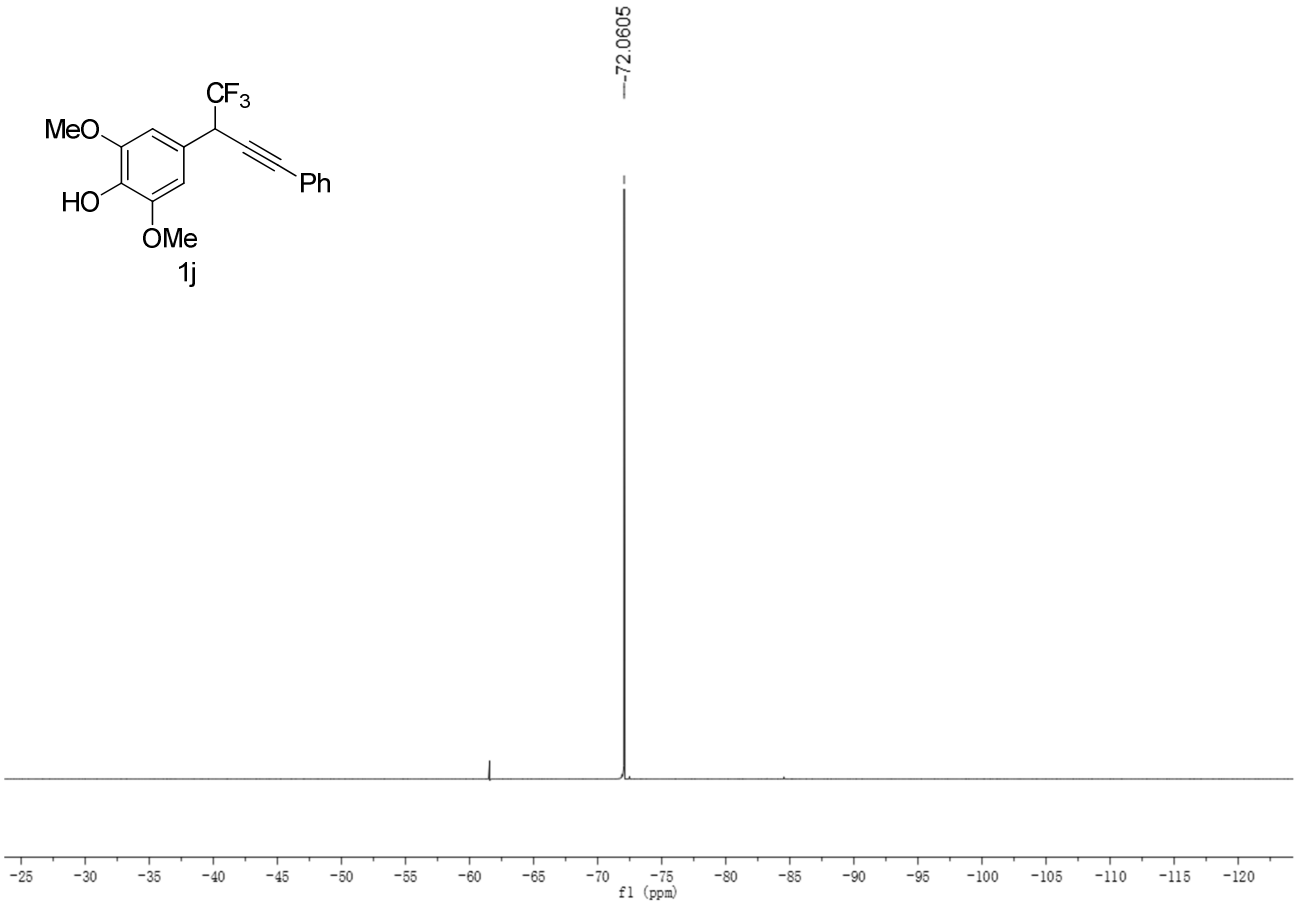
122.7620
107.9070
86.2527
83.2968
83.2696
83.2426
83.2159
56.8728
44.6995
44.4509
44.2020
43.9523
CF3
MeO
HO
OMe
Ph
1j
f1 (ppm)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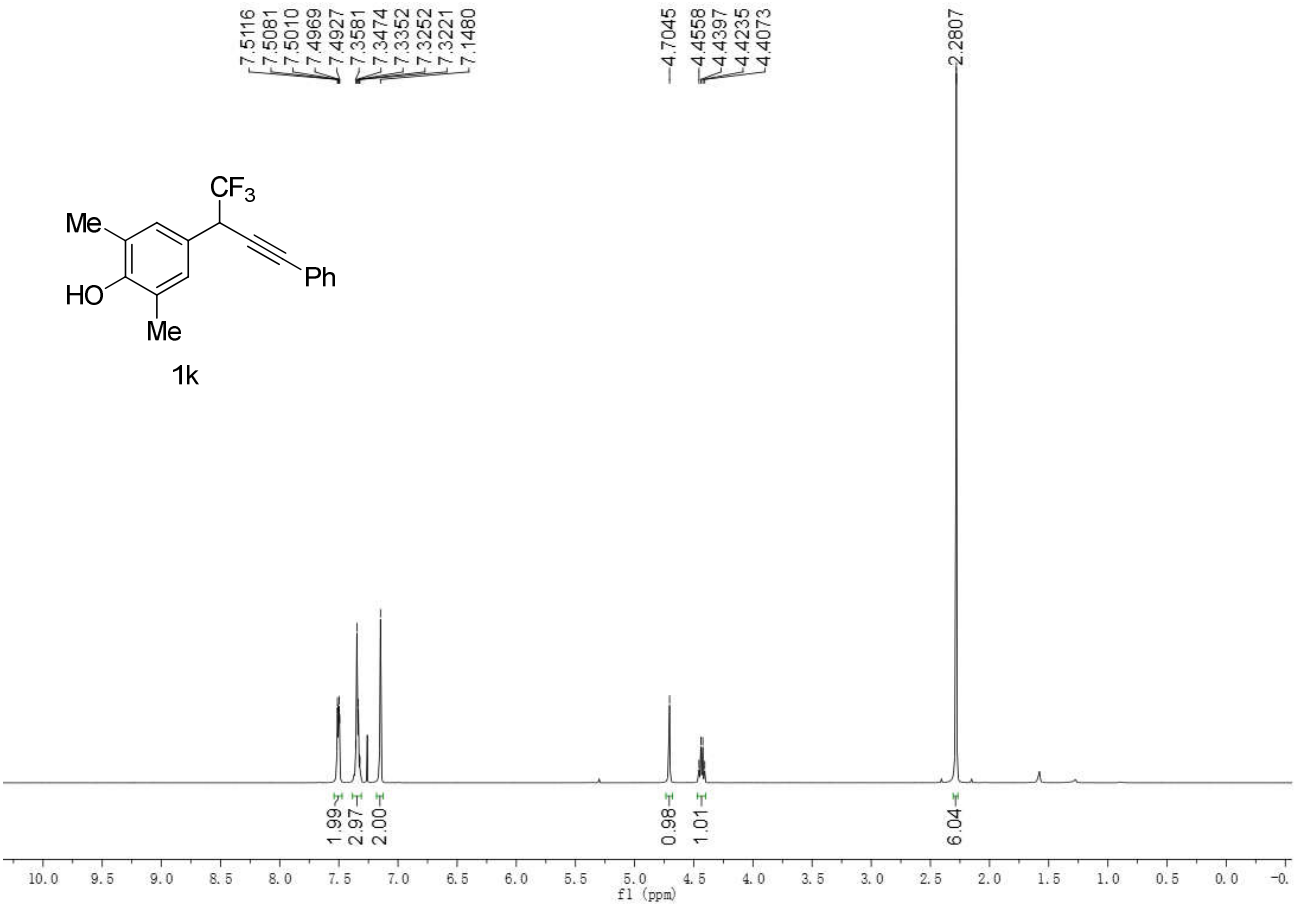
CF3
MeO
HO
OMe
Ph
1j
f1 (ppm)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7.5010
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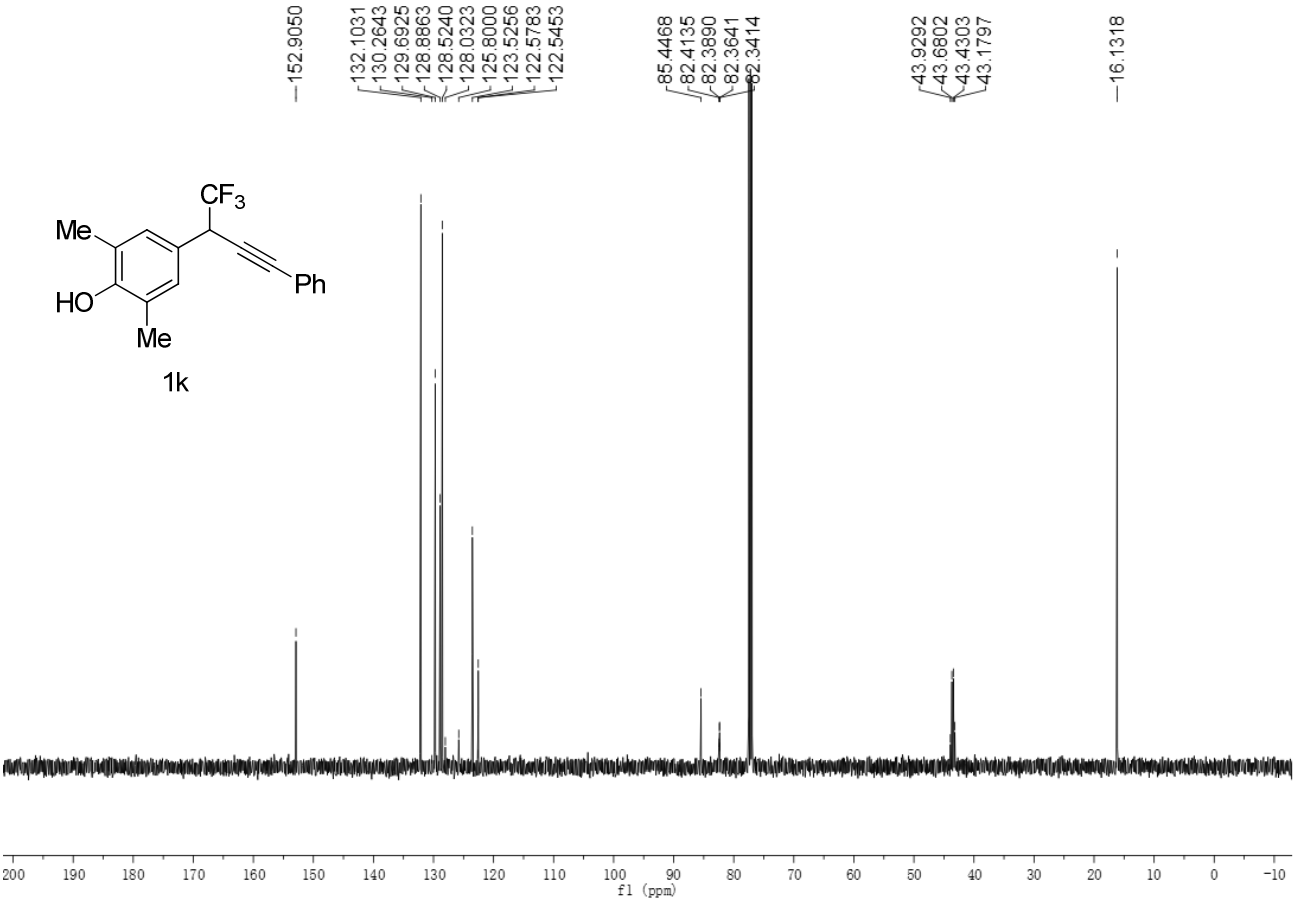
7.3474
7.3352
7.3252
7.3221
7.1480
4.7045
4.4558
4.4397
4.4235
4.4073
2.2807
CF3
Me
HO
Me
Ph
1k
1.99
2.97
2.00
0.98
1.01
6.04
f1 (ppm)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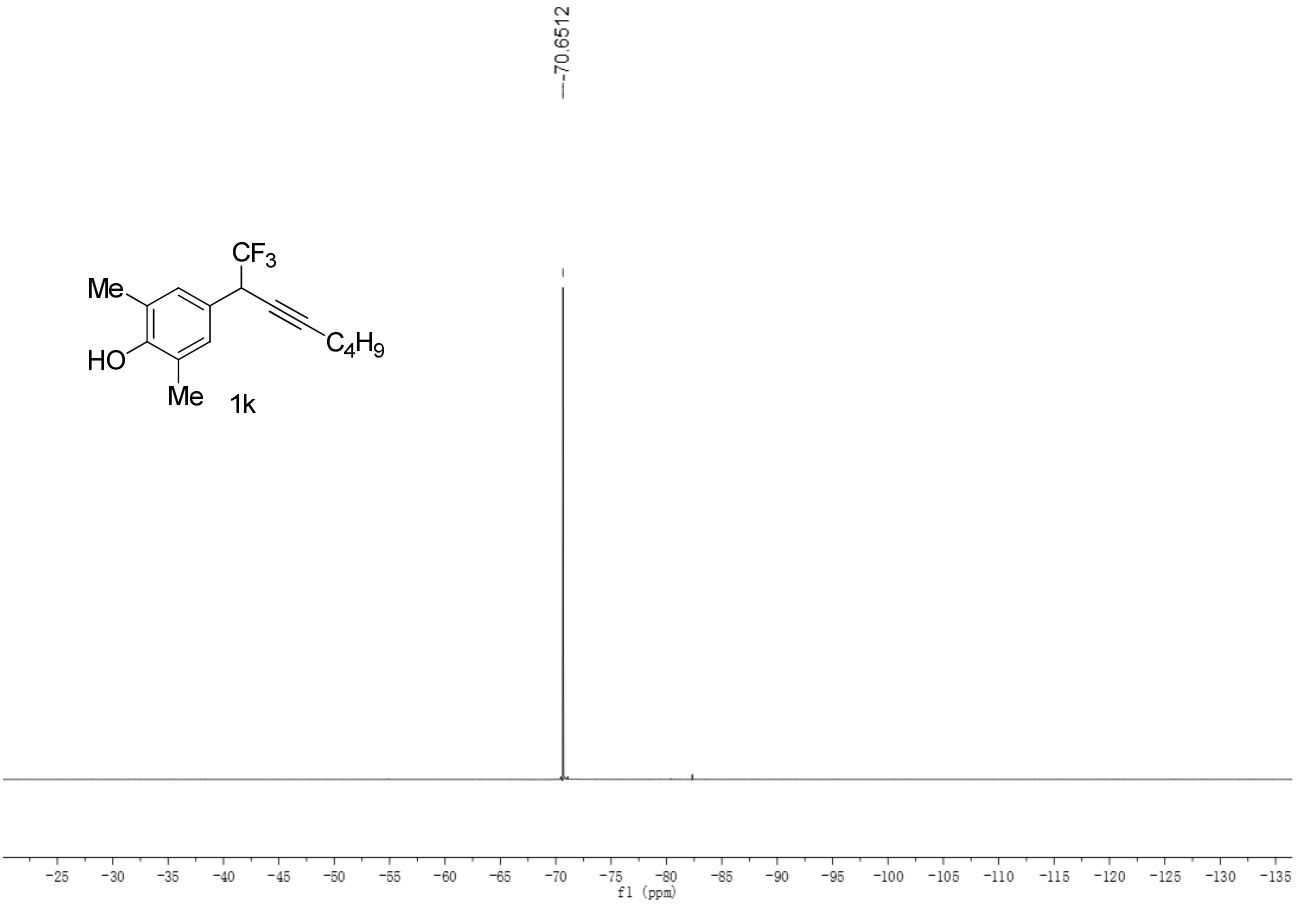
130.2643
129.6925
128.8863
128.5240
128.0323
125.8000
123.5256
122.5783
122.5453
85.4468
82.4135
82.3890
82.3641
82.3414
43.9292
43.6802
43.4303
43.1797
16.1318
CF3
Me
HO
Me
Ph
1k
f1 (ppm)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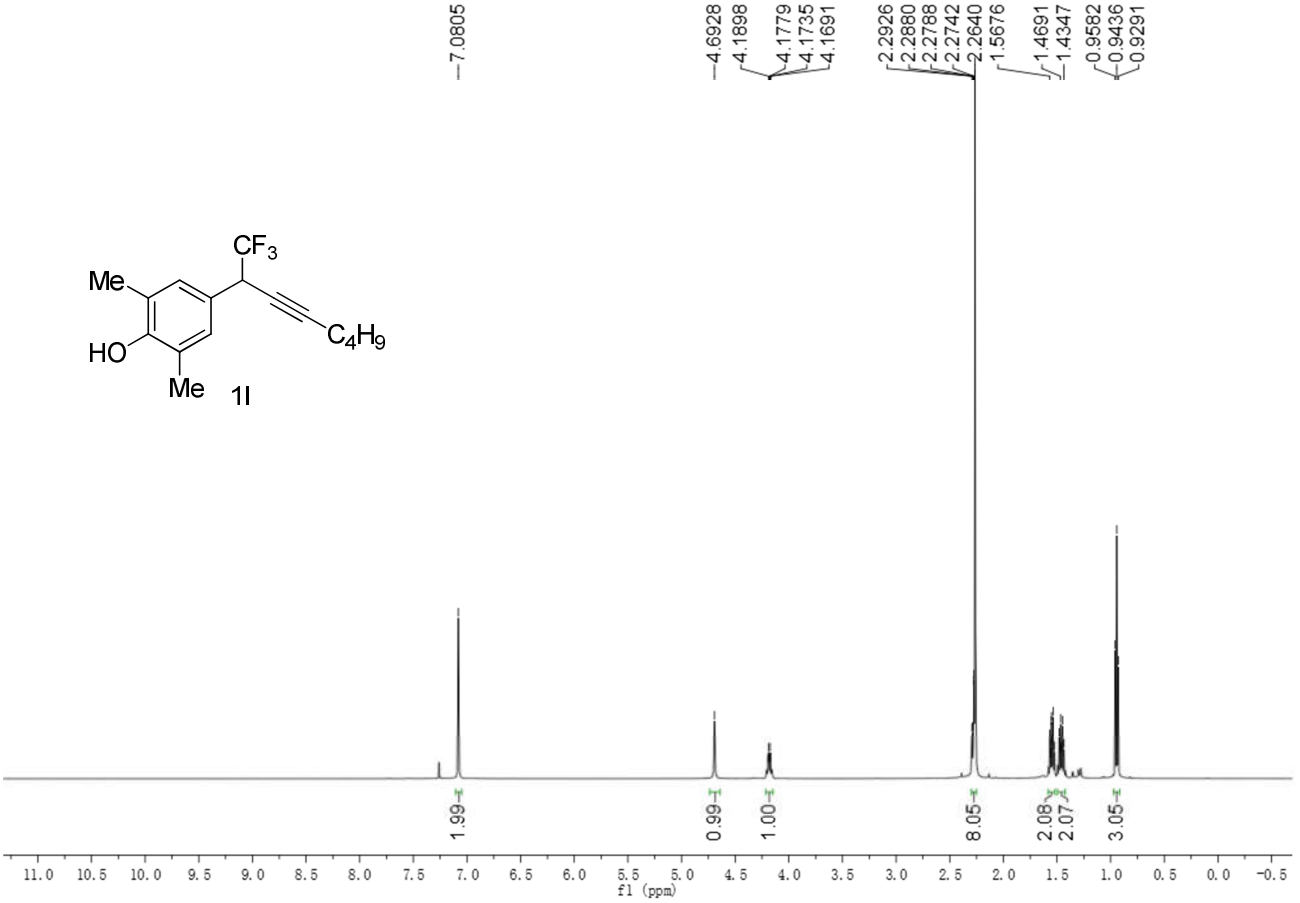
CF3
Me
HO
Me
C4H9
1k
f1 (ppm)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2.2926
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2.2788
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2.2640
1.5676
1.4691
1.4347
0.9582
0.9436
0.9291
CF3
Me
HO
Me
C4H9
1l
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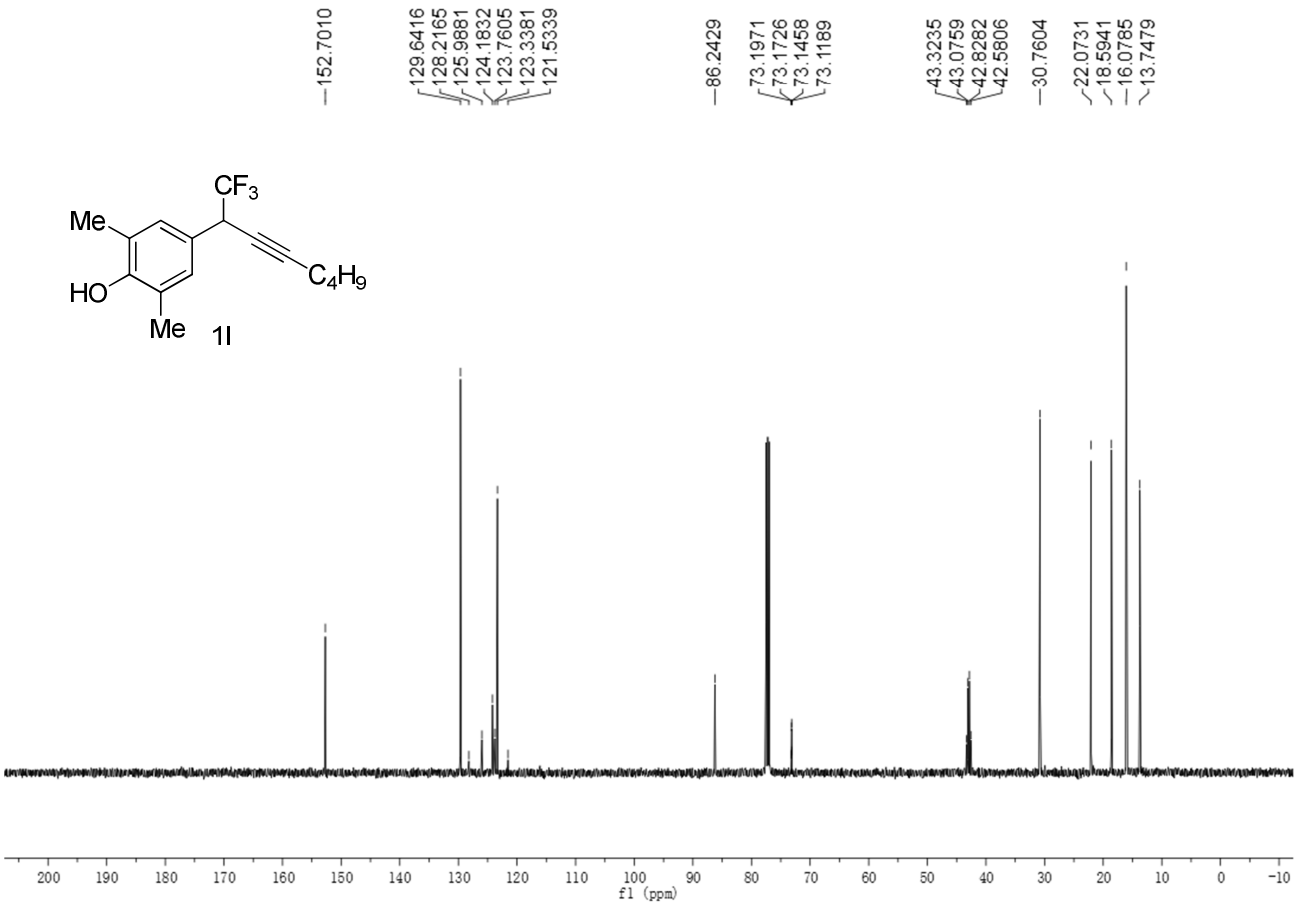
0.99
1.00
8.05
2.08
2.07
3.05
f1 (ppm)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73.1971
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73.1458
73.1189
43.3235
43.0759
42.8282
42.5806
30.7604
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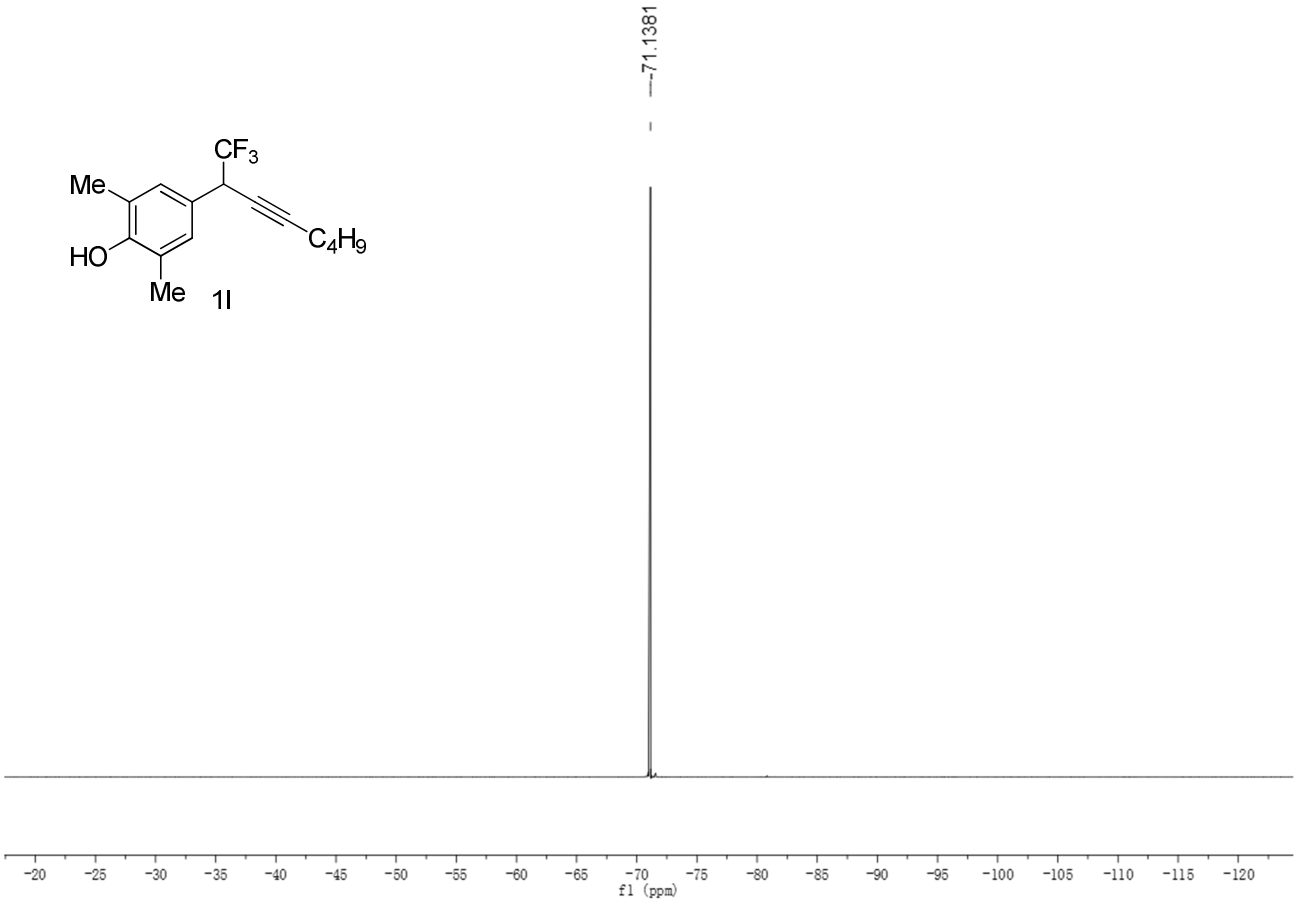
18.5941
16.0785
13.7479
CF3
Me
HO
Me
C4H9
1l
f1 (ppm)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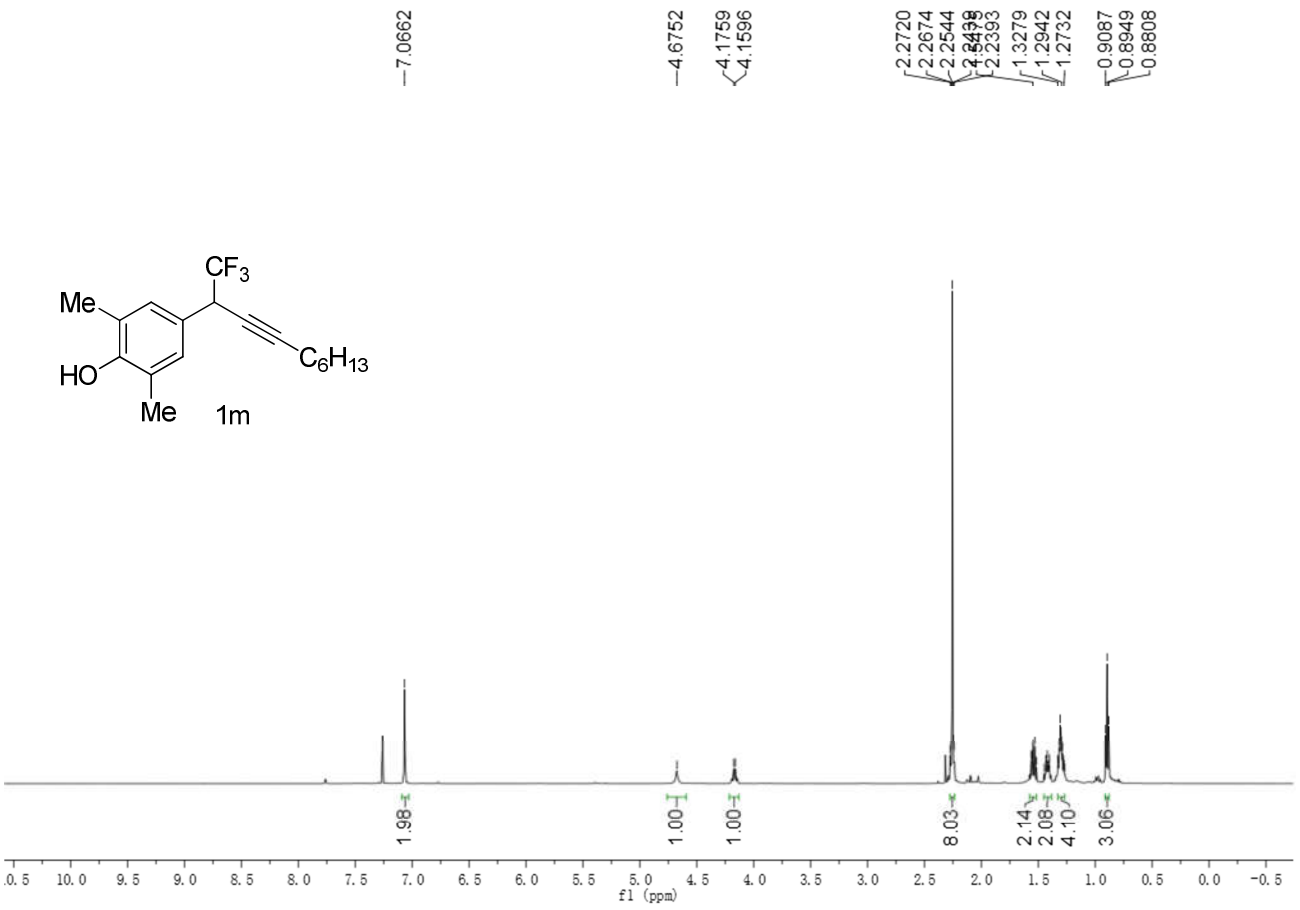
HO
Me
C4H9
1l
f1 (ppm)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1.3279
1.2942
1.2732
0.9087
0.8949
0.8808
CF3
Me
HO
Me
C6H13
1m
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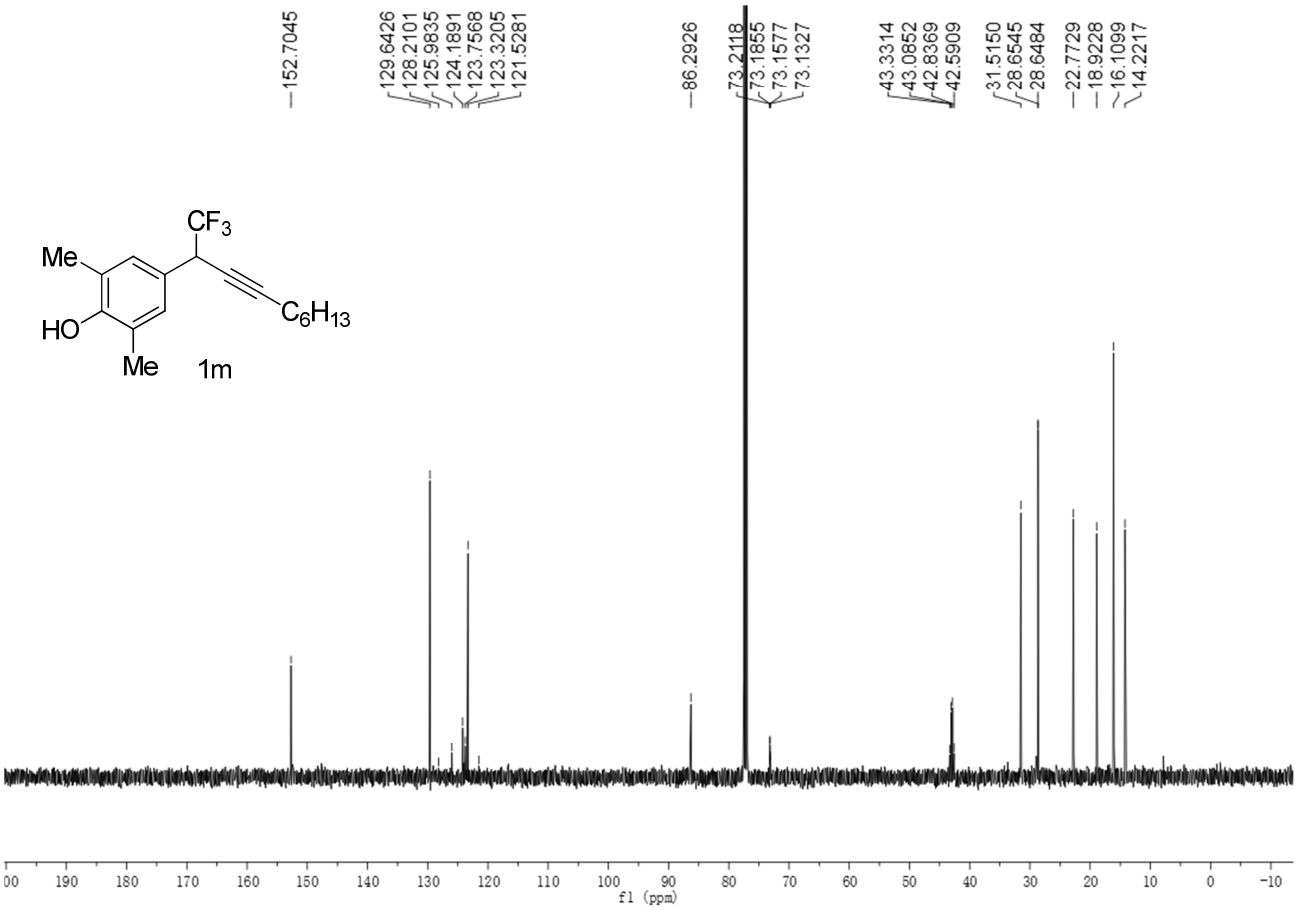
1.00
1.00
8.03
2.14
2.08
4.10
3.06
f1 (ppm)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43.3314
43.0852
42.8369
42.5909
31.5150
28.6545
28.6484
22.7729
18.9228
16.1099
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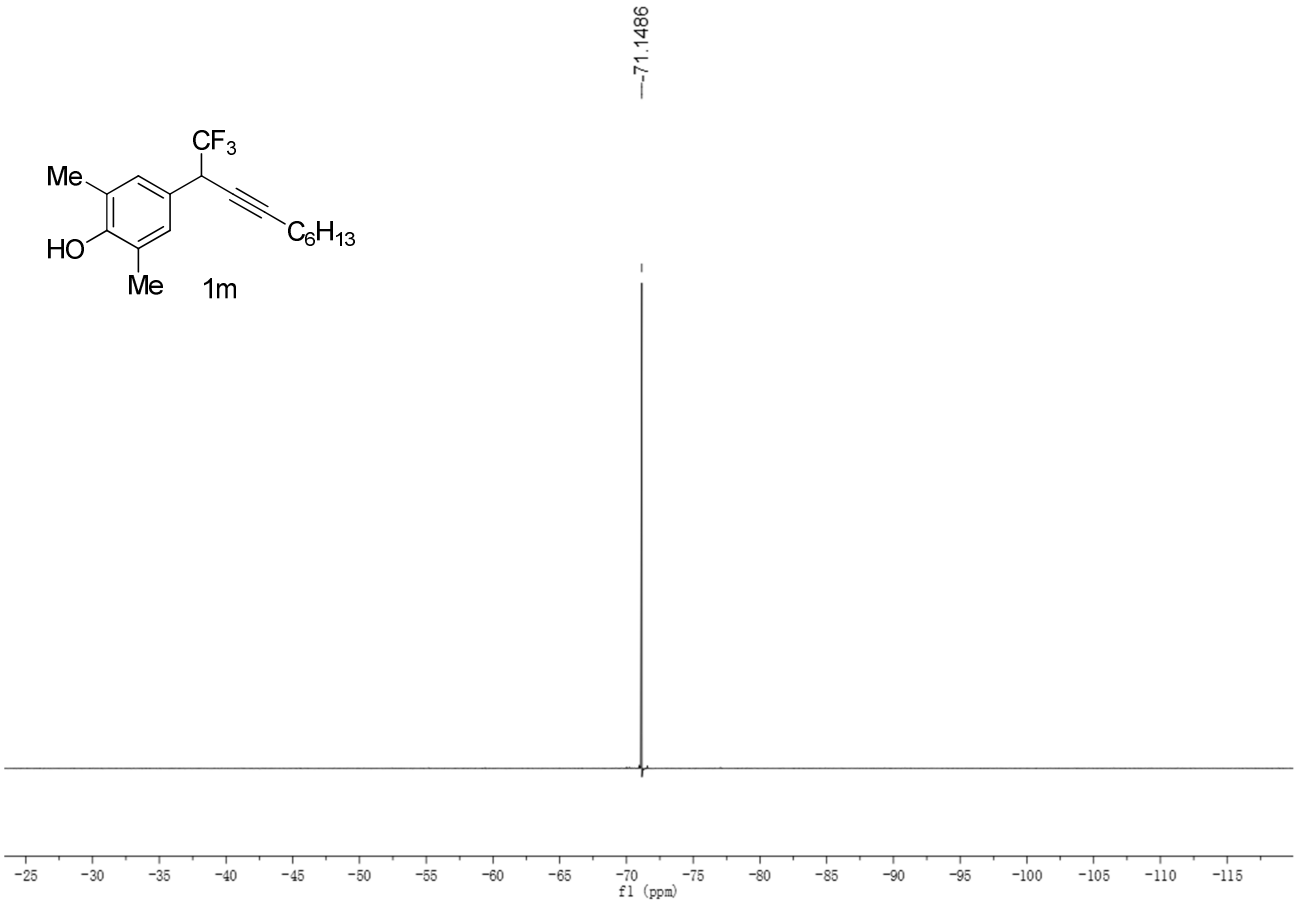
CF3
Me
HO
Me
C6H13
1m
f1 (ppm)

CF3
Me
HO
Me
C6H13

1m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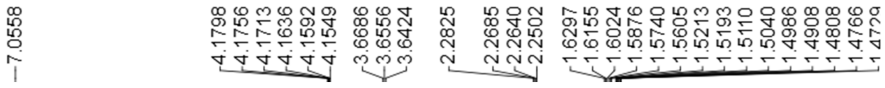
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)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3.6556
3.6424
2.2825
2.2685
2.2640
2.2502
1.6297
1.6155
1.6024
1.5876
1.5740
1.5605
1.5213
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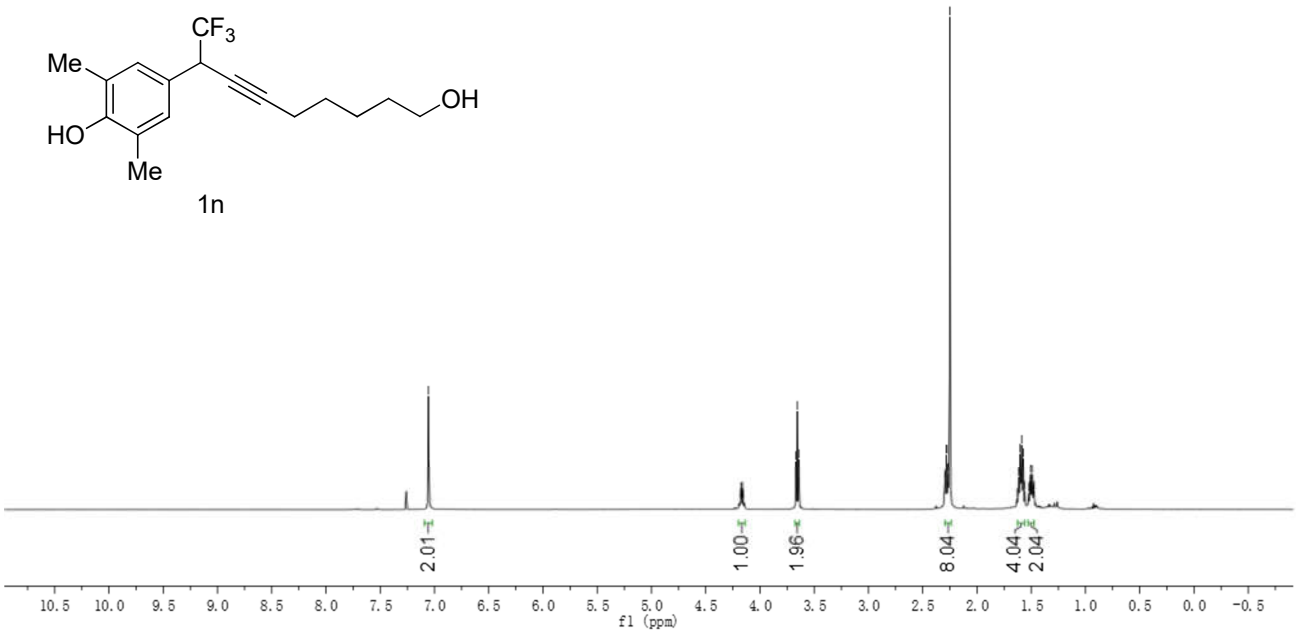
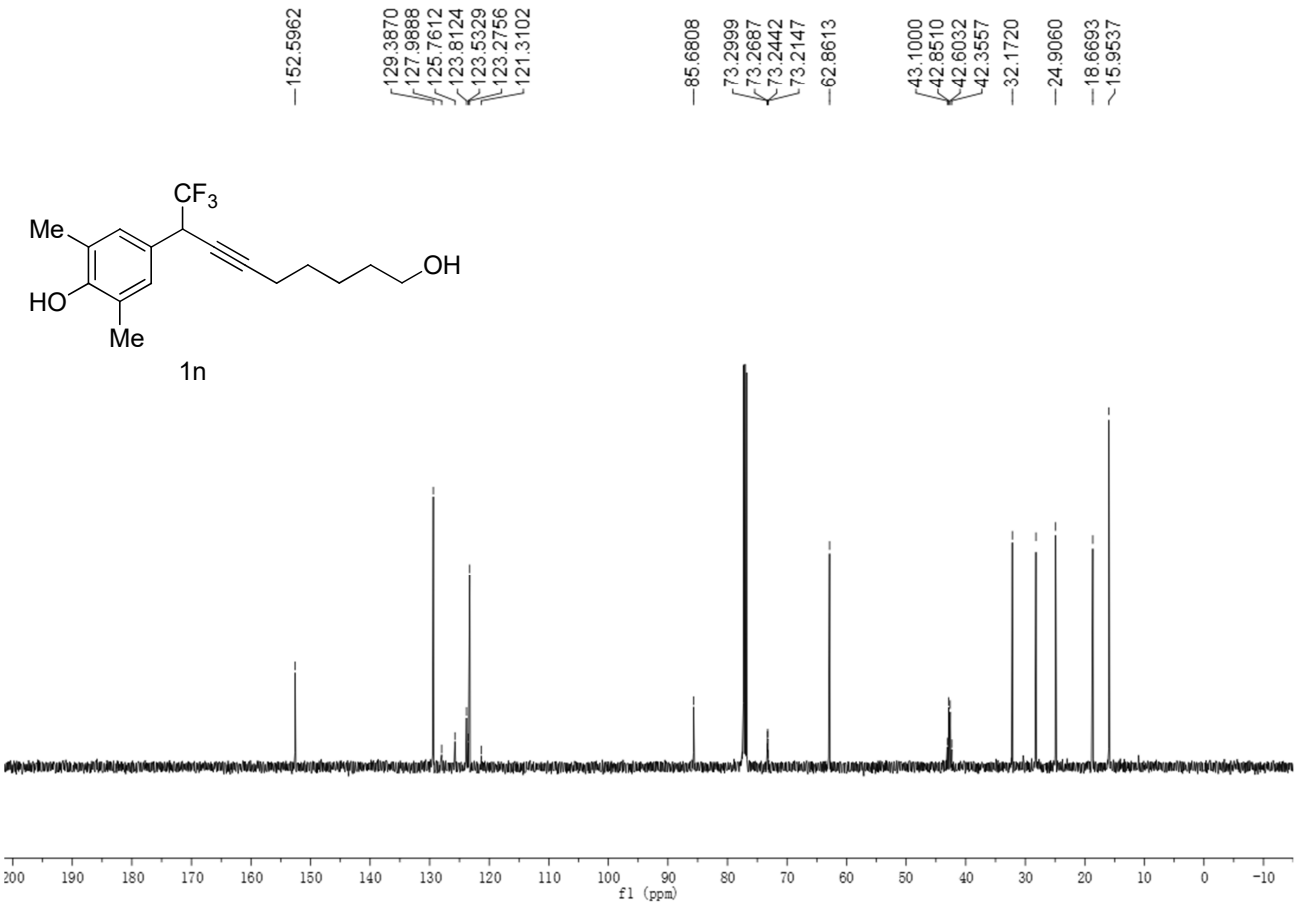
1.4986
1.4908
1.4808
1.4766

CF3
Me
HO
Me
OH

1n


2.01
1.00
1.96
8.04
4.04
2.04
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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123.2756
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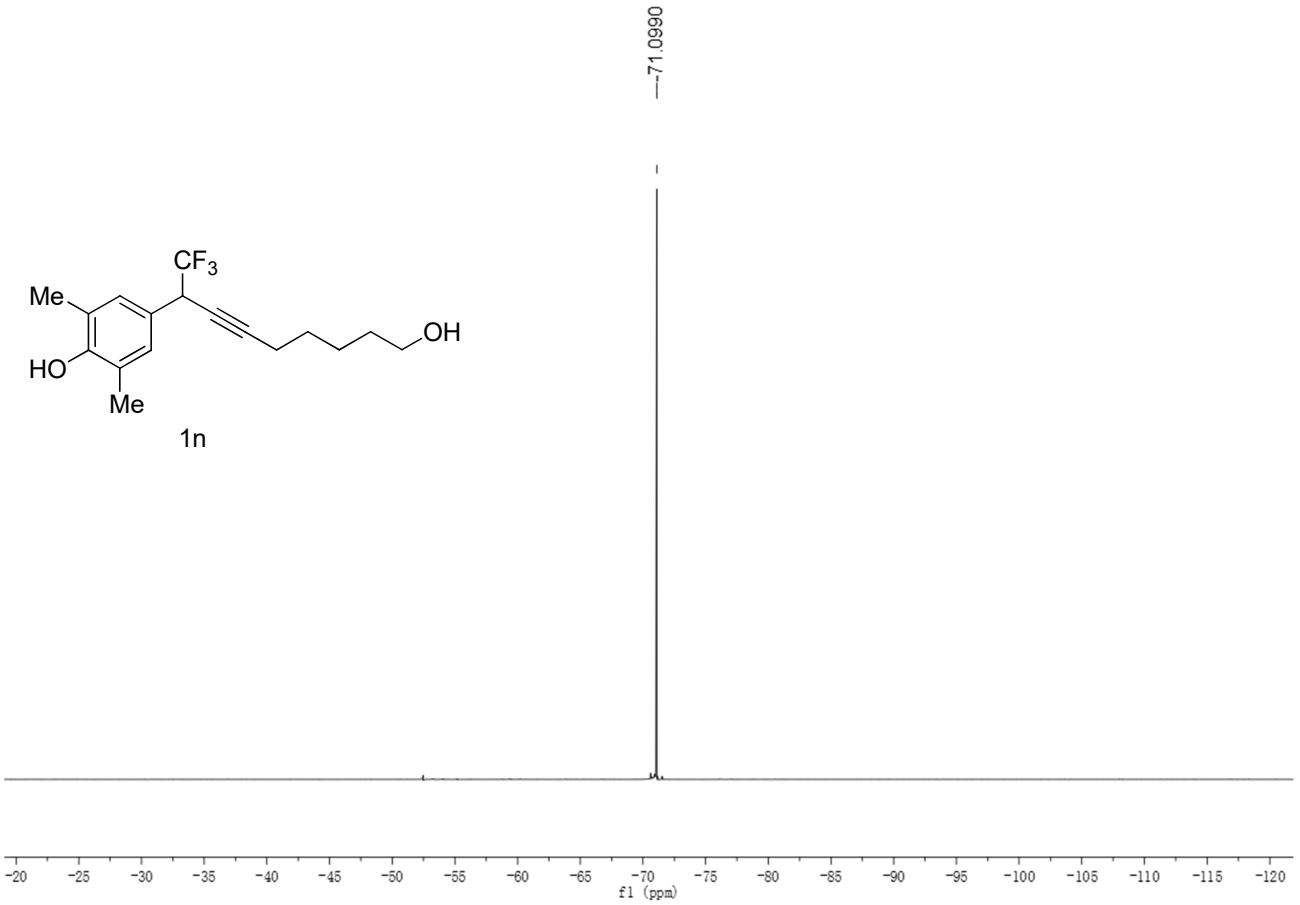
73.2687
73.2442
73.2147
62.8613
43.1000
42.8510
42.6032
42.3557
32.1720
24.9060
18.6693
15.9537
CF3
Me
HO
Me
OH
1n
f1 (ppm)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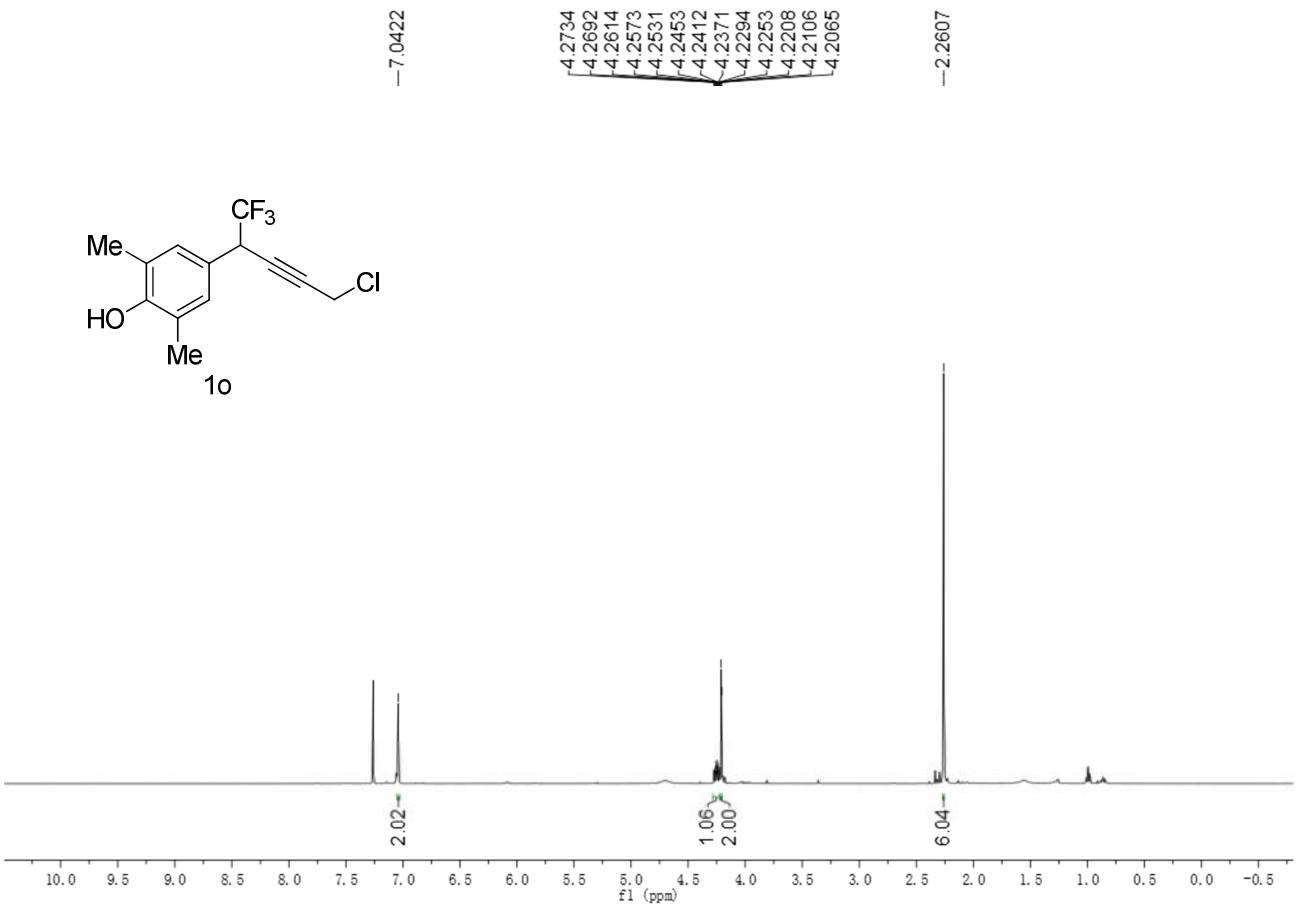
HO
Me
OH
1n
f1 (ppm)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4.2453
4.2412
4.2371
4.2294
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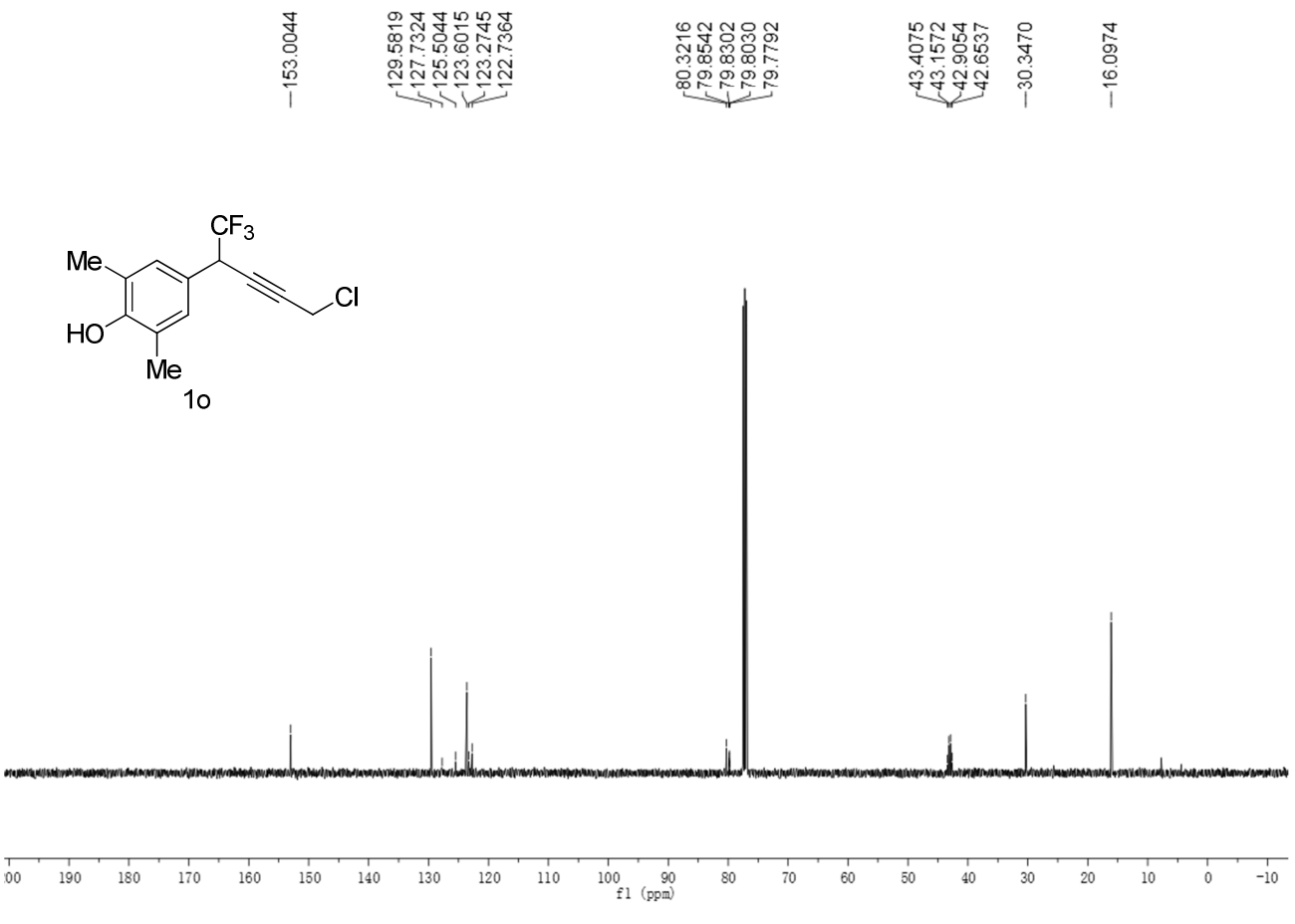
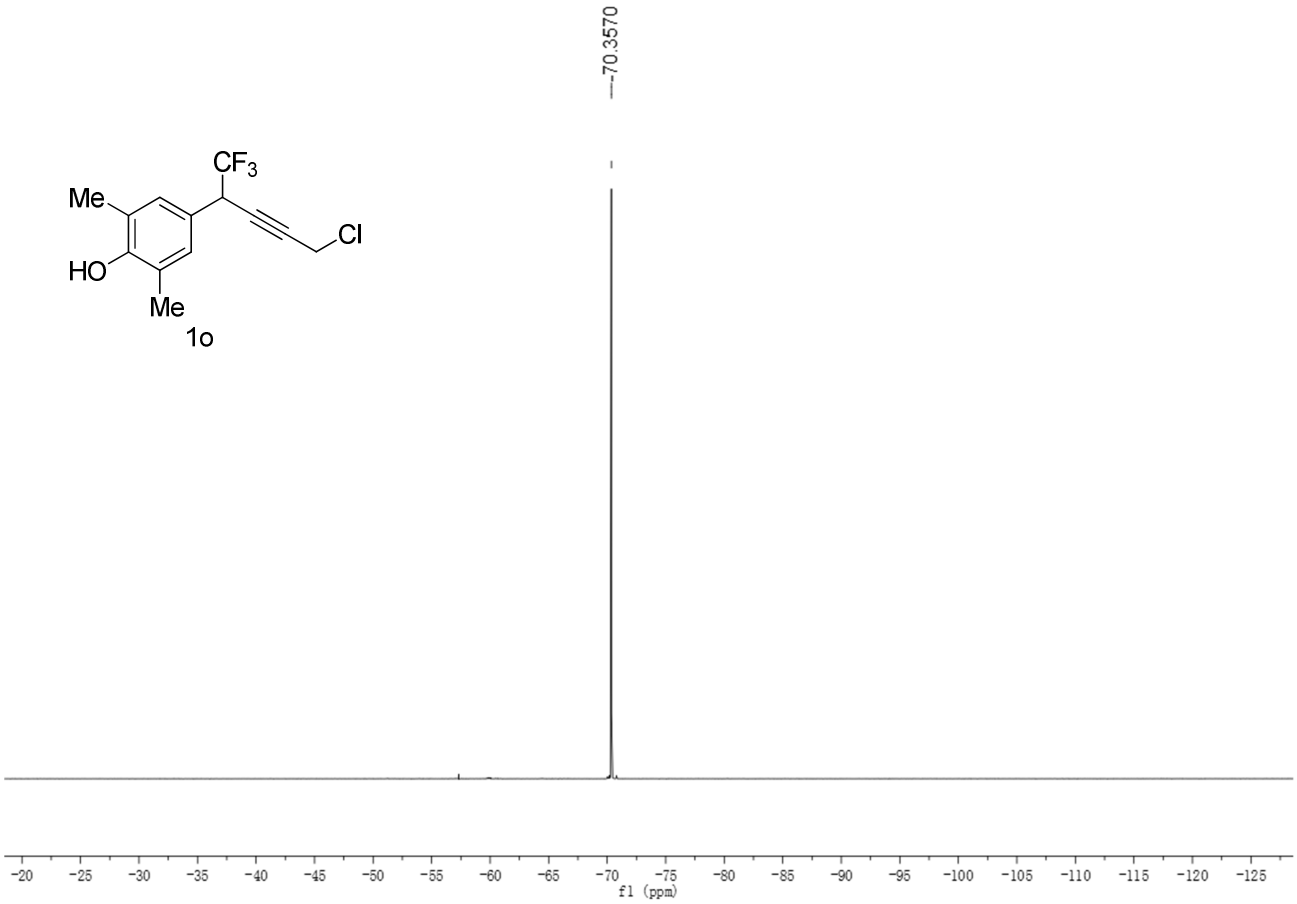
4.2208
4.2106
4.2065
2.2607
CF3
Me
HO
Me
Cl
1o
2.02
1.06
2.00
6.04
f1 (ppm)


153.0044
129.5819
127.7324
125.5044
123.6015
123.2745
122.7364
80.3216
79.8542
79.8302
79.8030
79.7792
43.4075
43.1572
42.9054
42.6537
30.3470
16.0974
CF3
Me
HO
Me
Cl
1o
f1 (ppm)

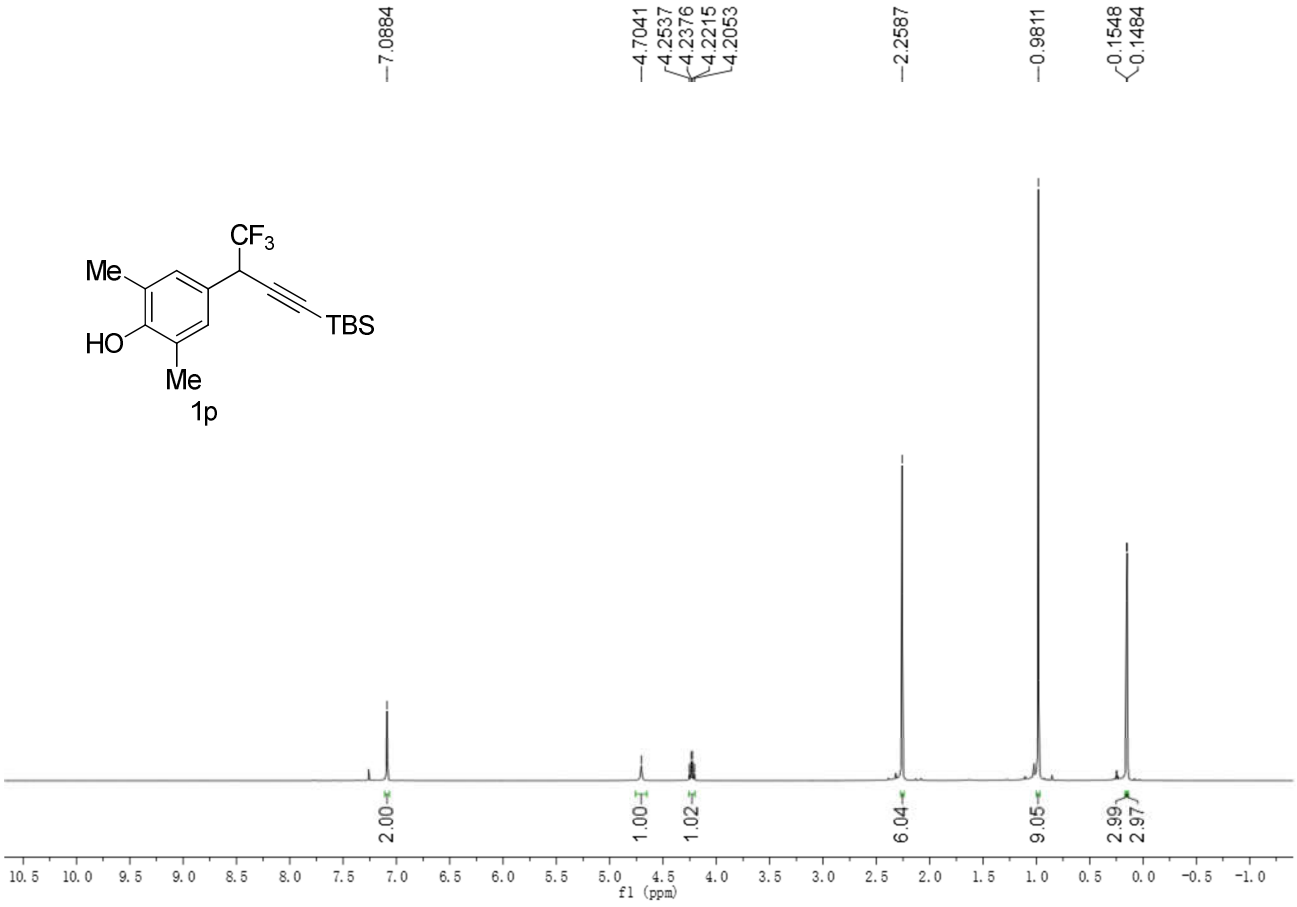
CF3
Me
Cl
HO
Me

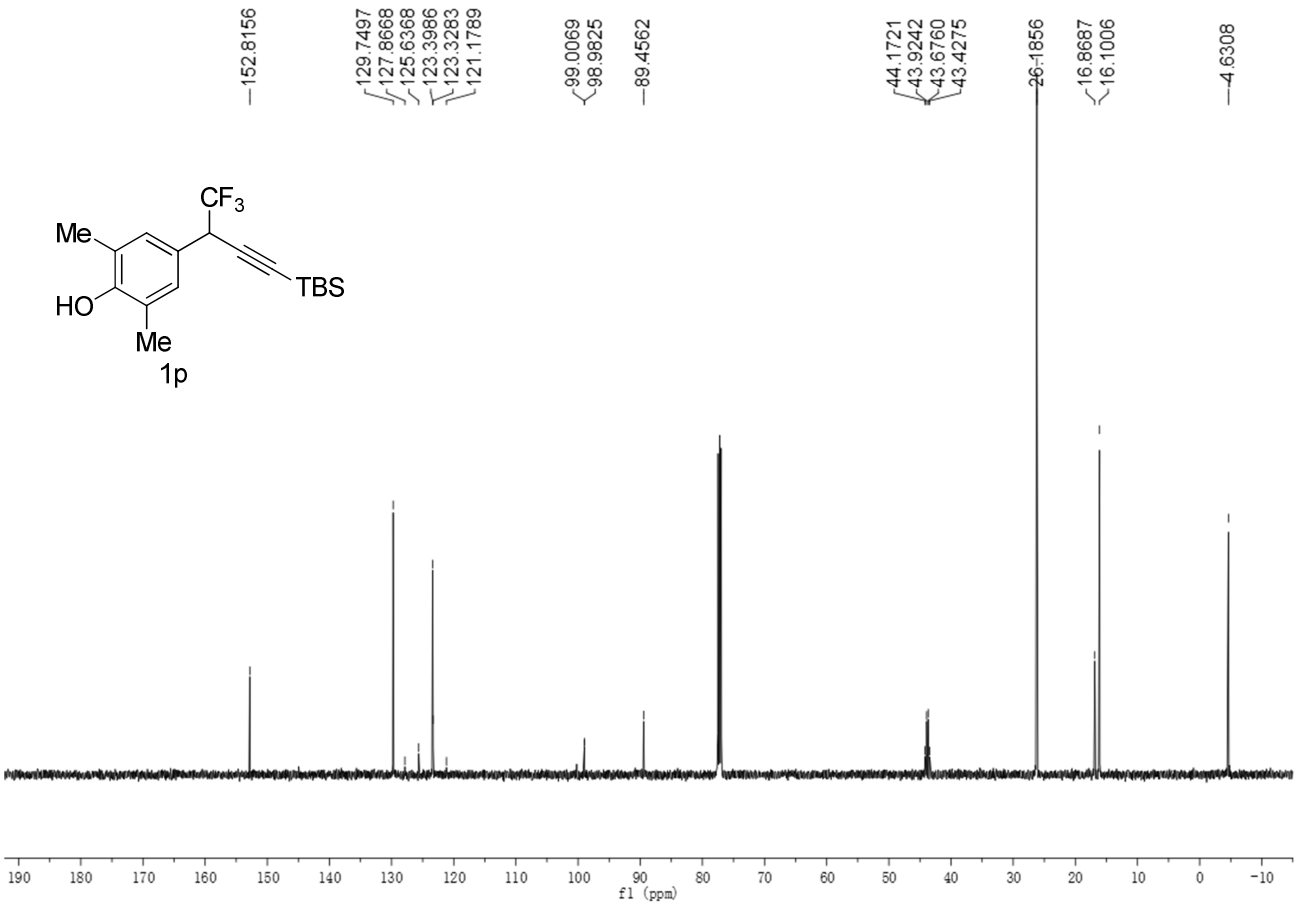
1o


-70.3570
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125
f1 (ppm)

CF3
Me
TBS
HO
Me

1p


7.0884
4.7041
4.2537
4.2376
4.2215
4.2053
2.2587
0.9811
0.1548
0.1484
2.00
1.00
1.02
6.04
9.05
2.99
2.97
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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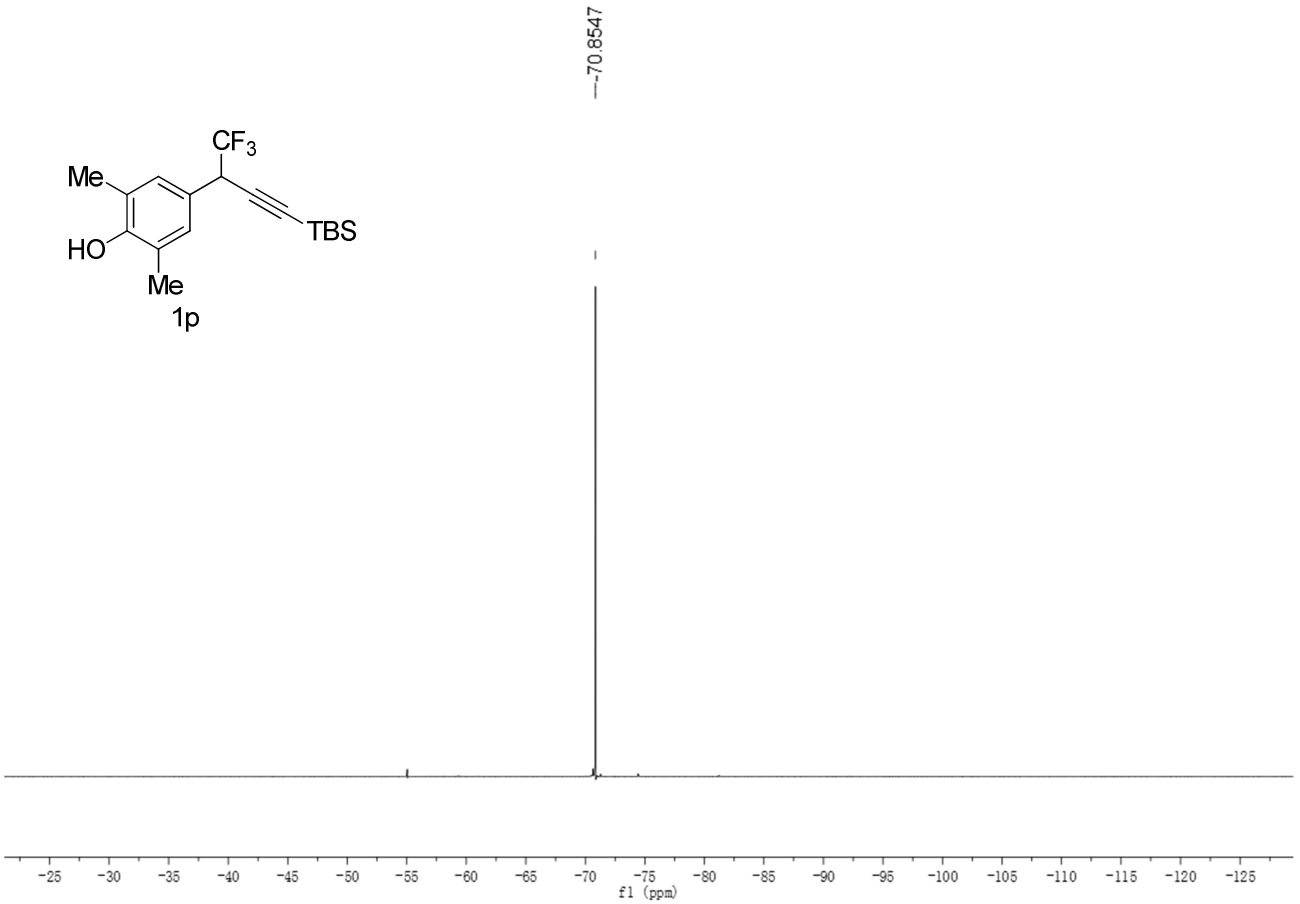
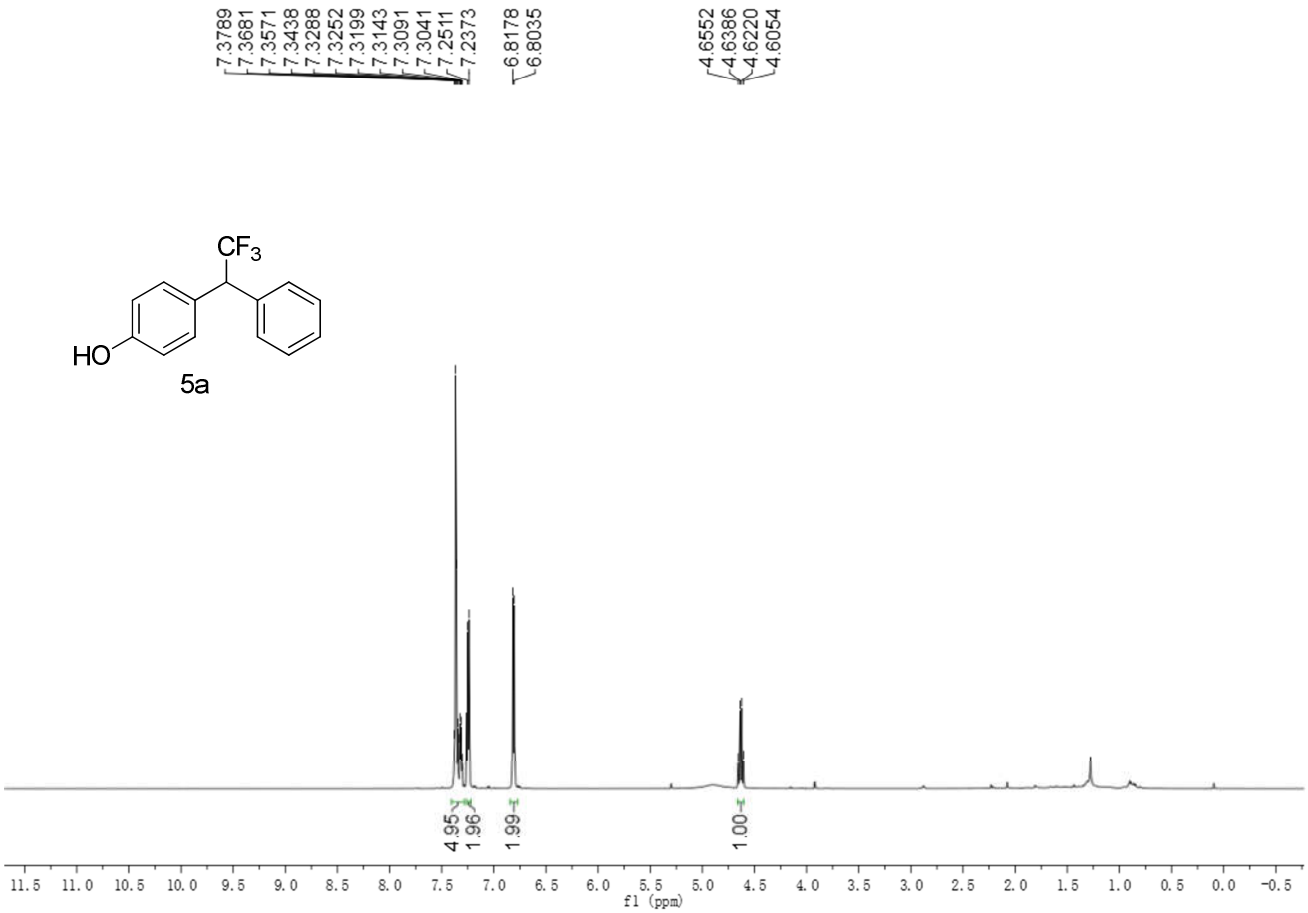
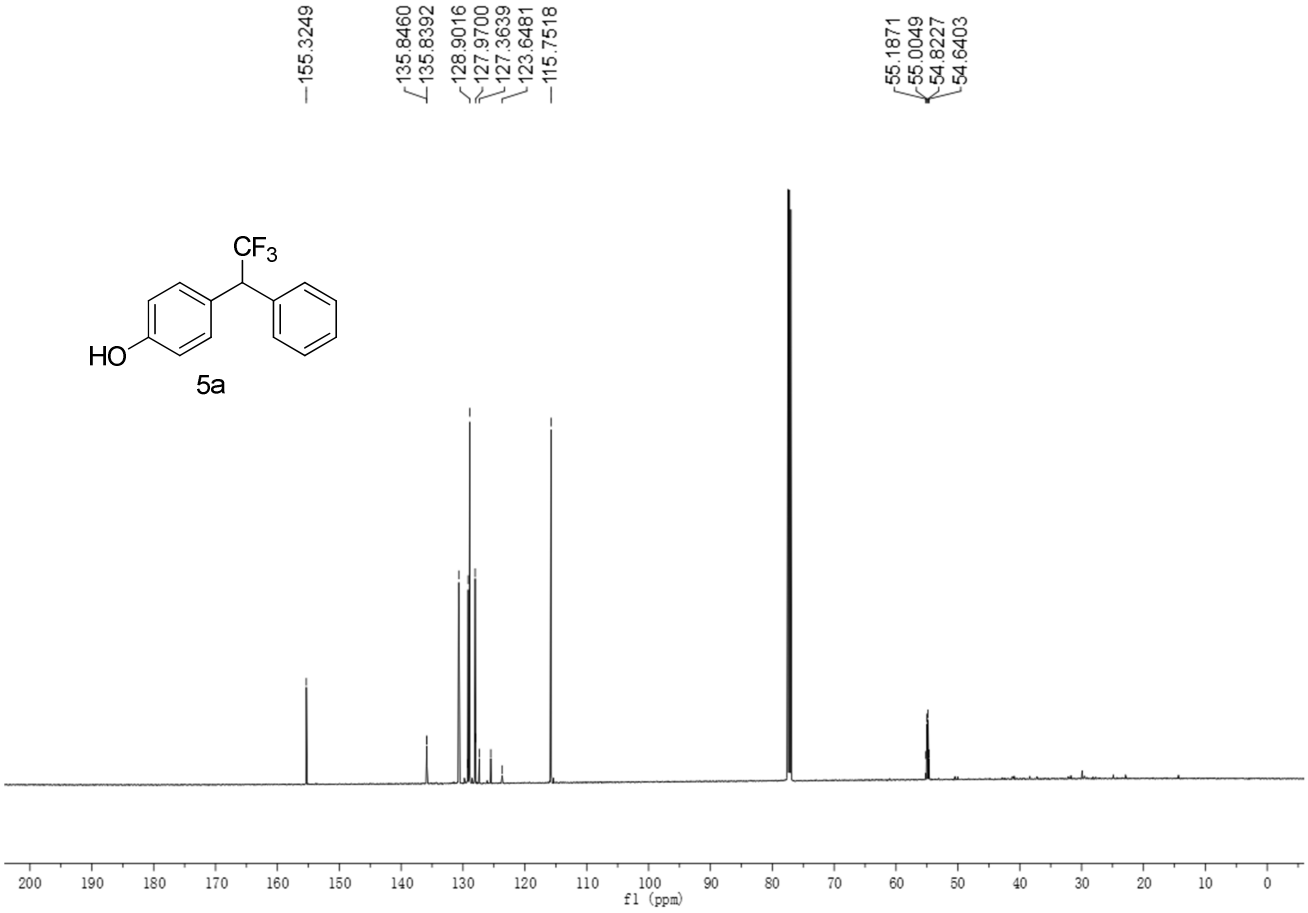
129.7497
127.8668
125.6368
123.3986
123.3283
121.1789
99.0069
98.9825
89.4562
44.1721
43.9242
43.6760
43.4275
26.1856
16.8687
16.1006
4.6308
CF3
Me
HO
Me
TBS
1p
f1 (ppm)

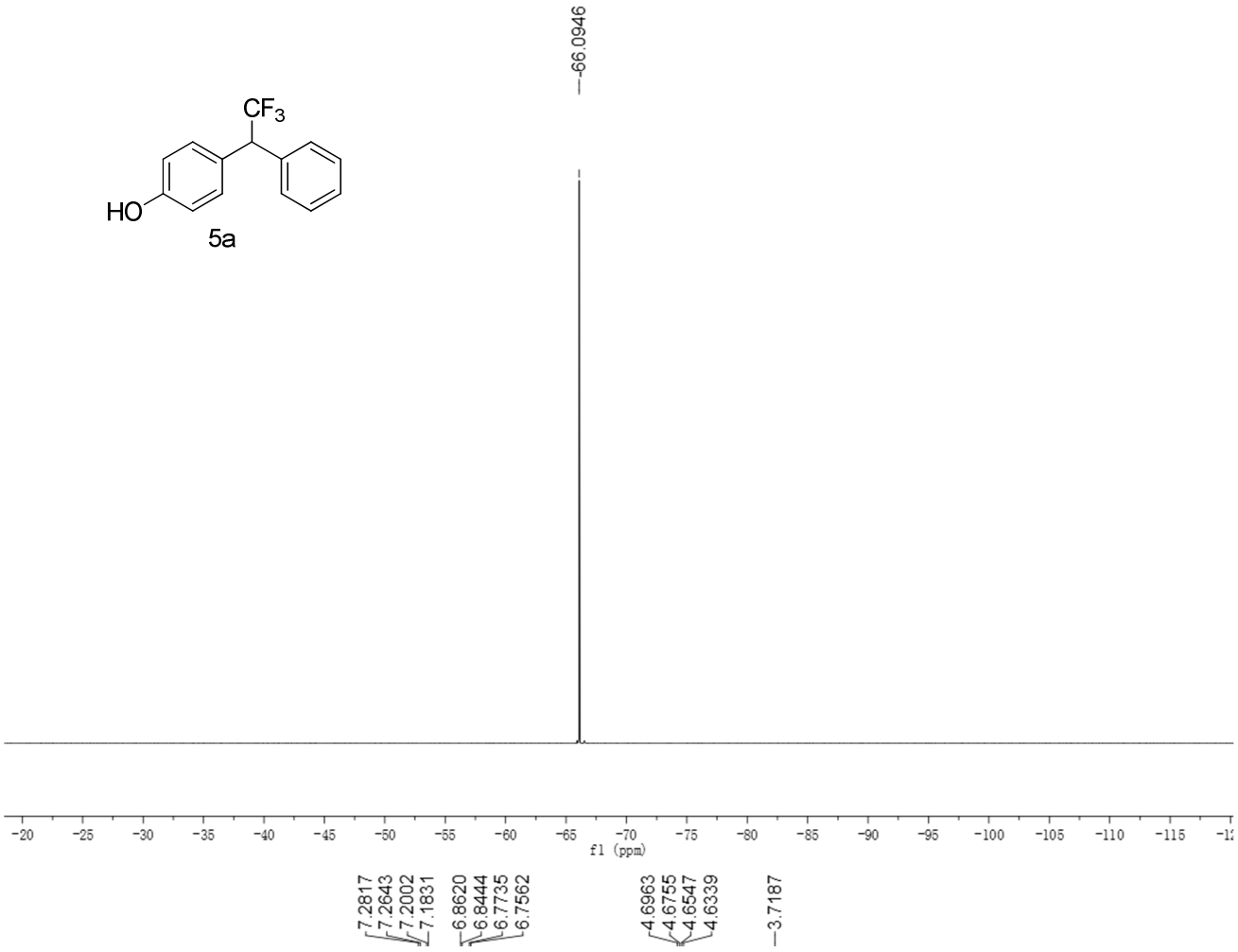

70.8547
CF3
Me
HO
Me
TBS
1p
f1 (ppm)


7.3789
7.3681
7.3571
7.3438
7.3288
7.3252
7.3199
7.3143
7.3091
7.3041
7.2511
7.2373
6.8178
6.8035
4.6552
4.6386
4.6220
4.6054
CF3
HO
5a
4.95
1.96
1.99
1.00
f1 (ppm)


155.3249
135.8460
135.8392
128.9016
127.9700
127.3639
123.6481
115.7518
55.1871
55.0049
54.8227
54.6403
CF3
HO
5a
f1 (ppm)

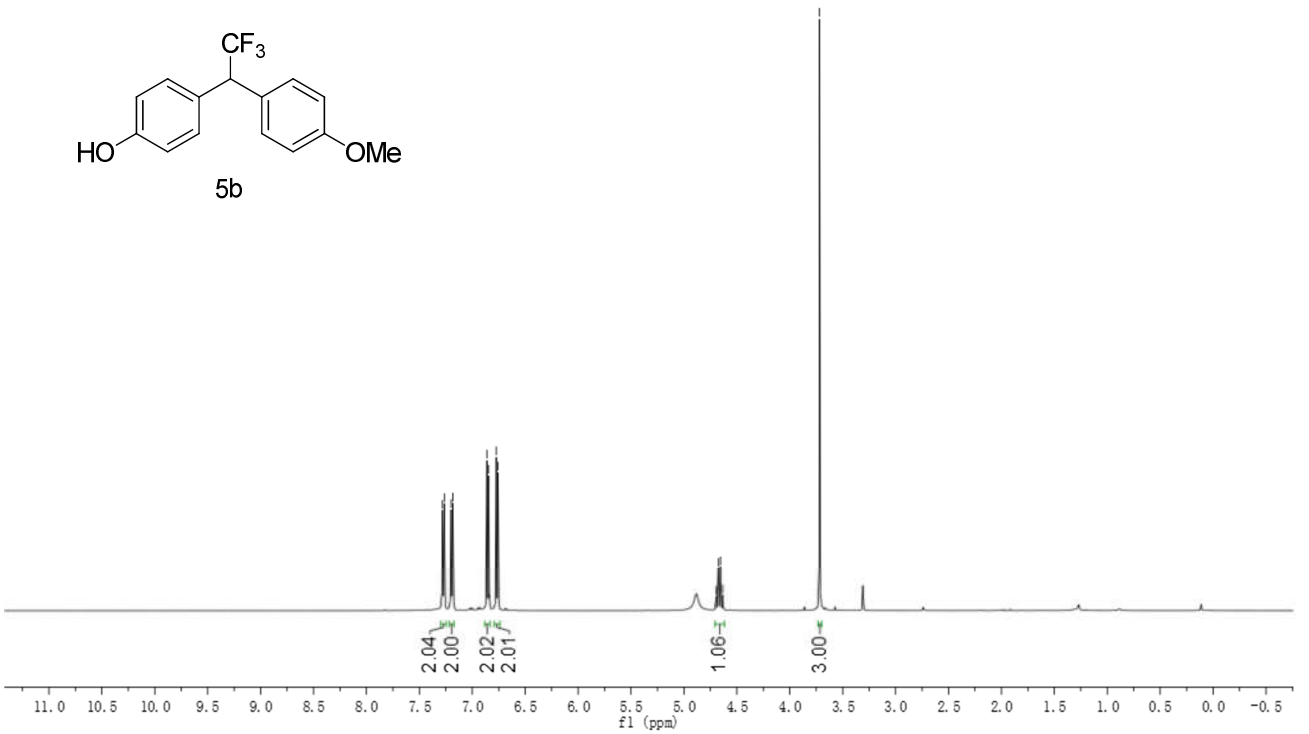
CF3
HO

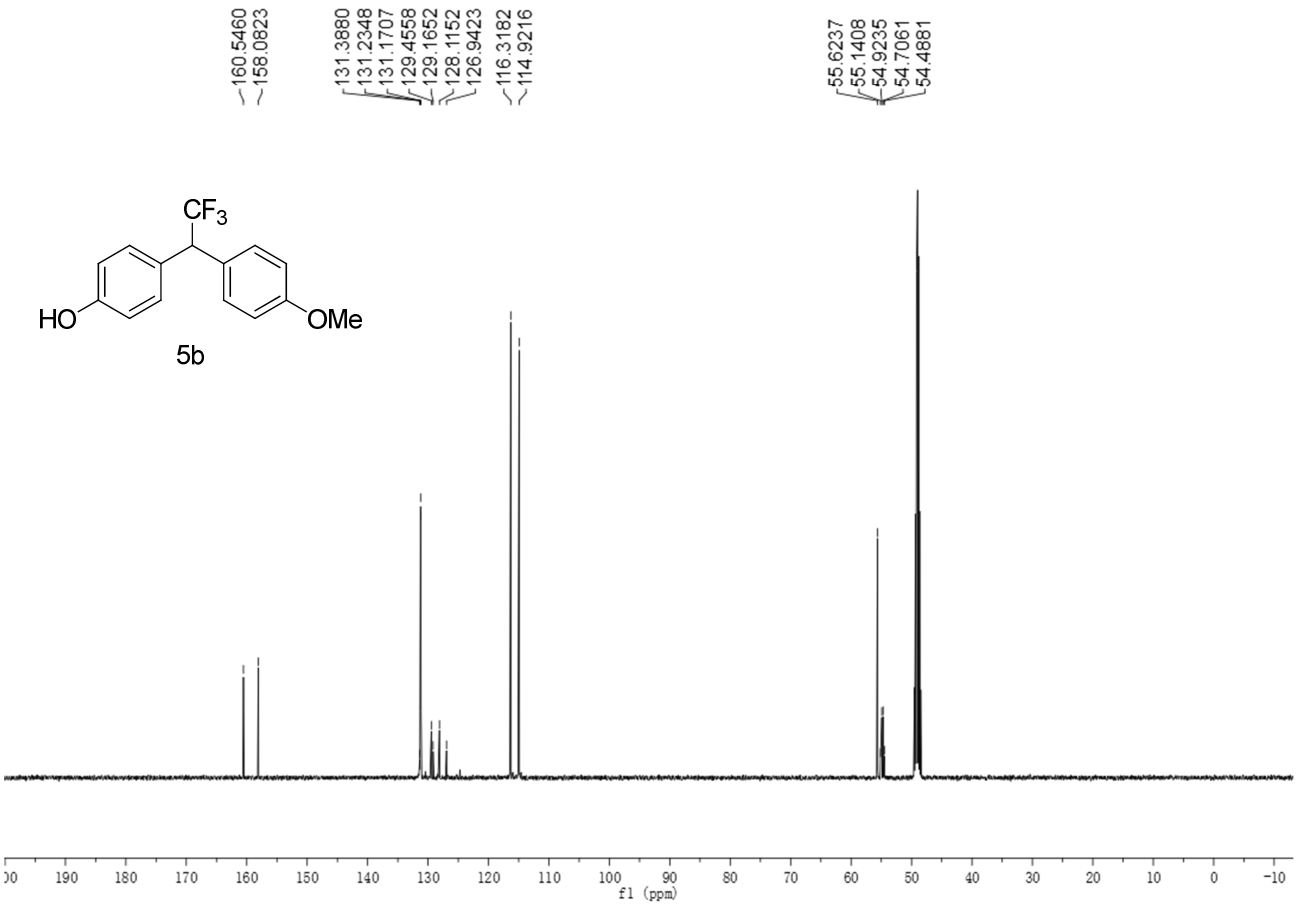
5a

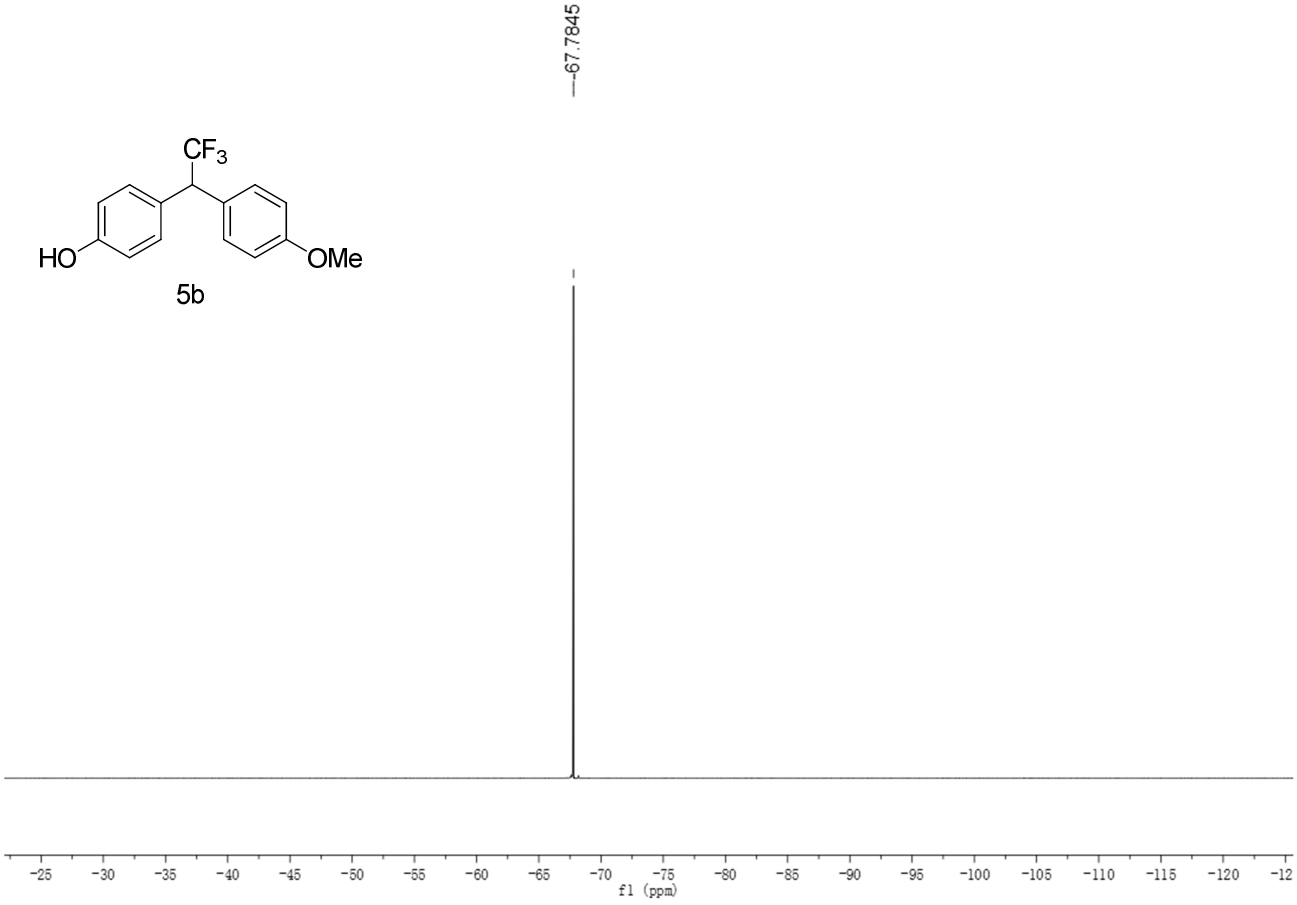

-66.0946
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)
7.2817
7.2643
7.2002
7.1831
6.8620
6.8444
6.7735
6.7562
4.6963
4.6755
4.6547
4.6339
3.7187

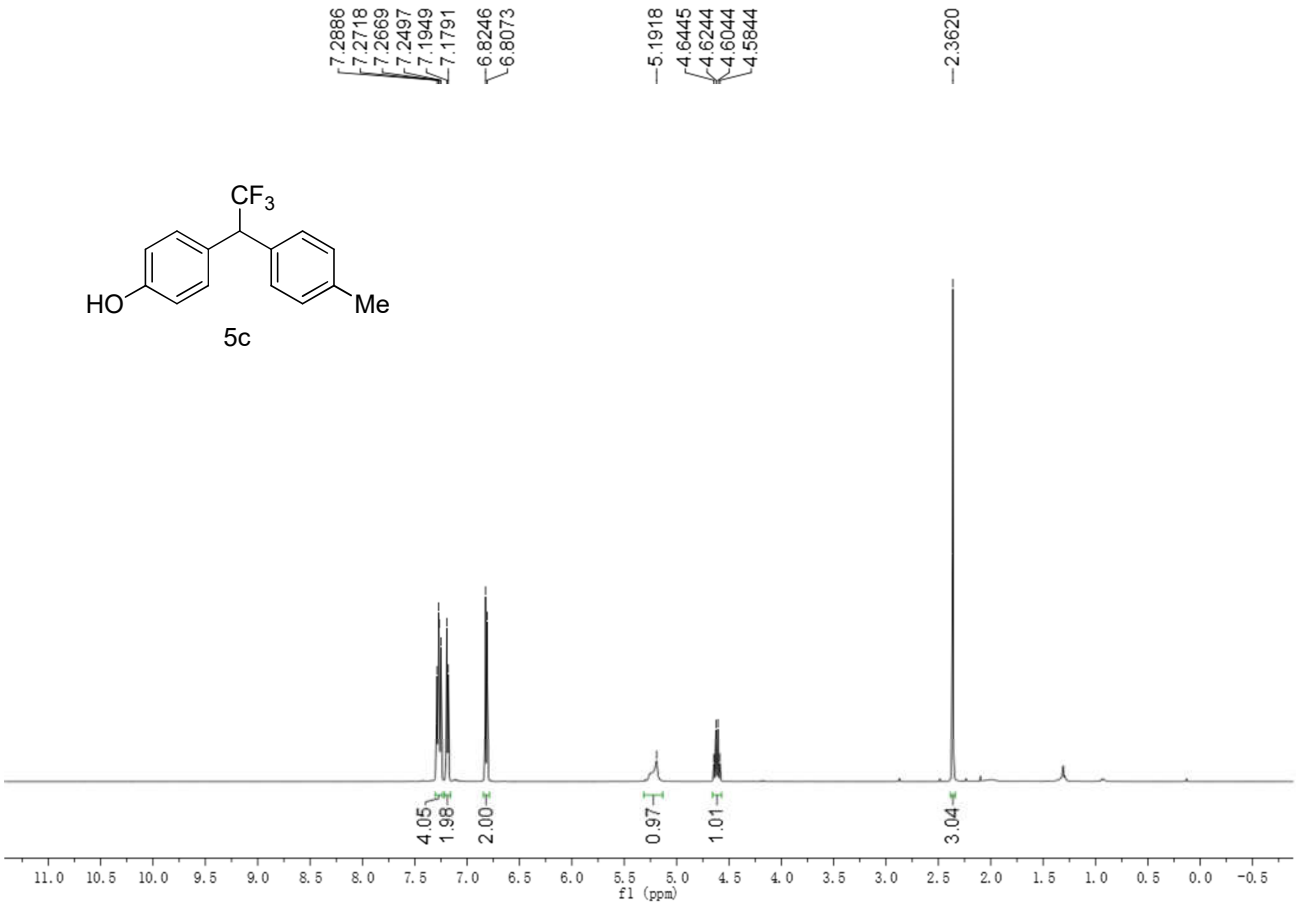
CF3
HO
OMe

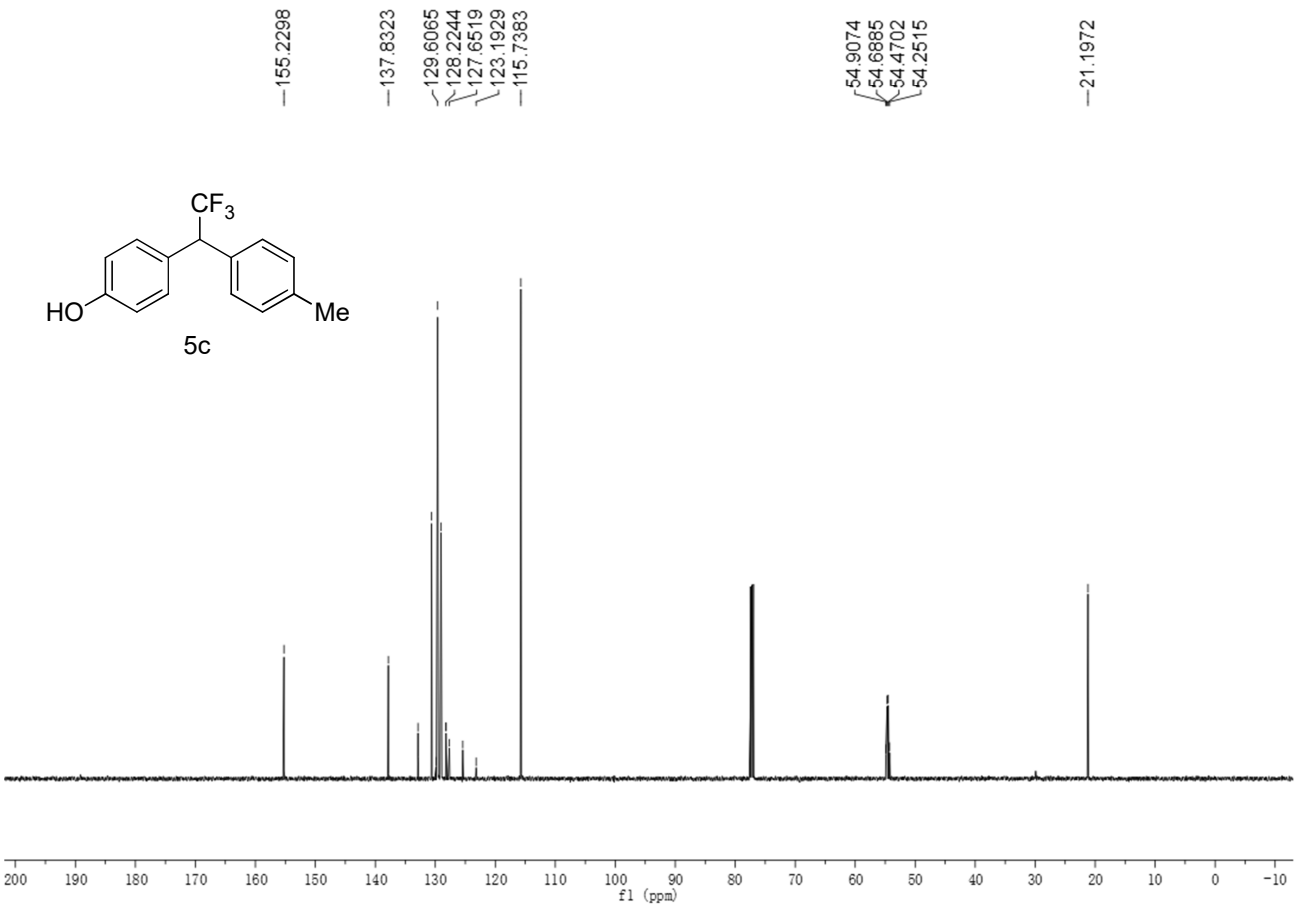
5b


2.04
2.00
2.02
2.01
1.06
3.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


160.5460
158.0823
131.3880
131.2348
131.1707
129.4558
129.1652
128.1152
126.9423
116.3182
114.9216
55.6237
55.1408
54.9235
54.7061
54.4881
CF3
HO
OMe
5b
f1 (ppm)


-67.7845
CF3
HO
OMe
5b
f1 (ppm)


7.2886
7.2718
7.2669
7.2497
7.1949
7.1791
6.8246
6.8073
5.1918
4.6445
4.6244
4.6044
4.5844
2.3620
CF3
HO
Me
5c
4.05
1.98
2.00
0.97
1.01
3.04
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


155.2298
137.8323
129.6065
128.2244
127.6519
123.1929
115.7383
54.9074
54.6885
54.4702
54.2515
21.1972
CF3
HO
Me
5c
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

CF3
HO
Me

5c


-66.1679
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125
f1 (ppm)


7.3355
7.3312
7.3226
7.3180
7.3139
7.2962
7.2790
7.2118
7.1946
6.8252
6.8078
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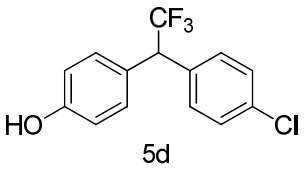
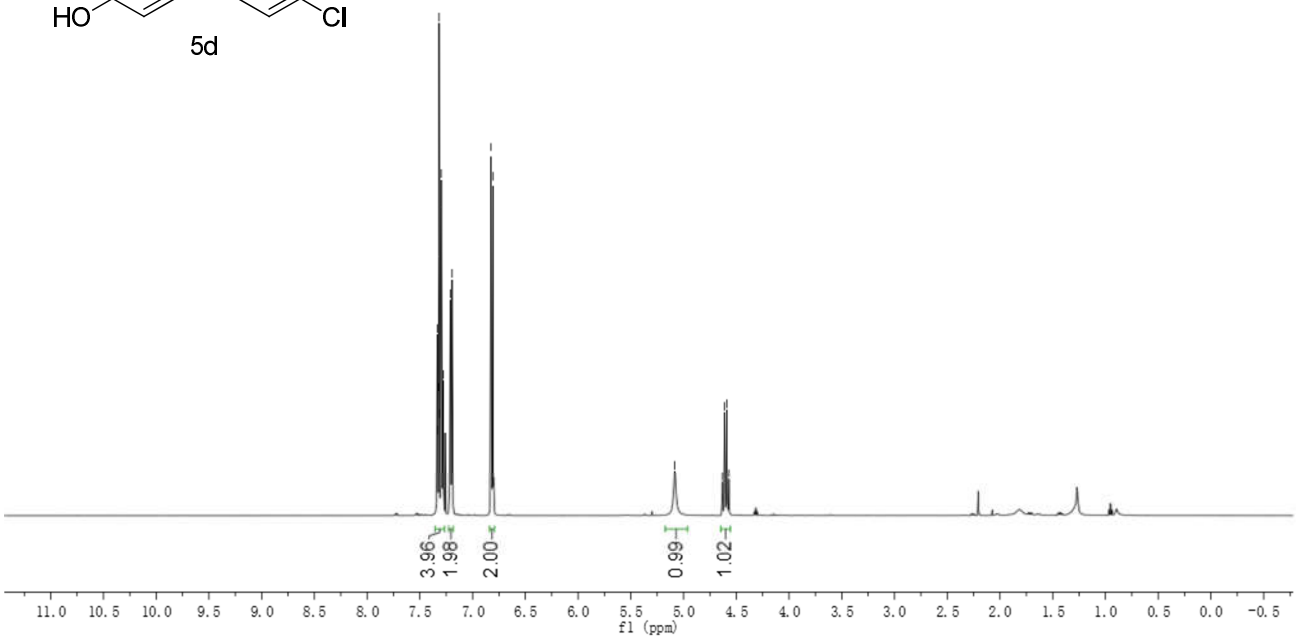
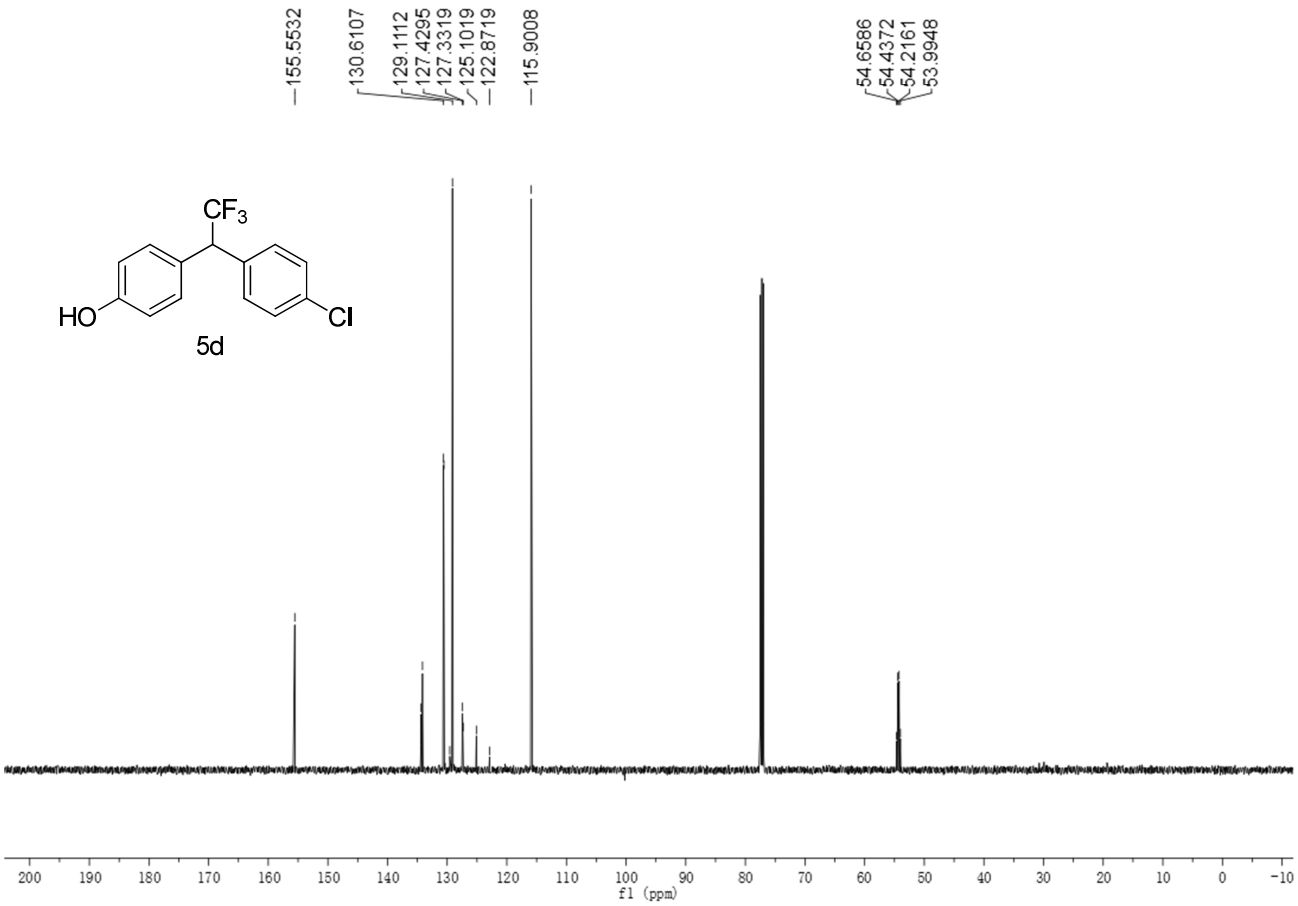
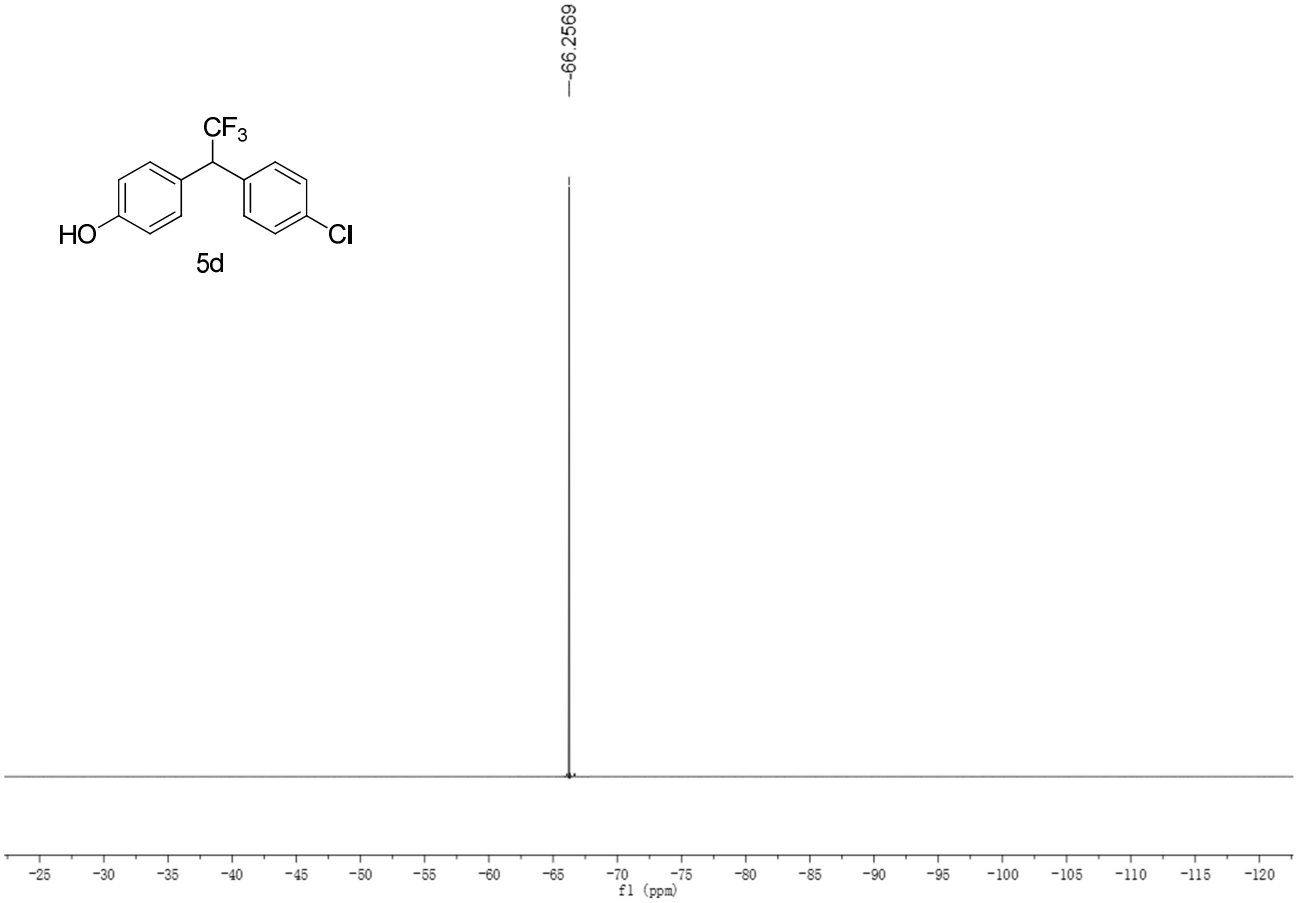
4.6105
4.5909
4.5712

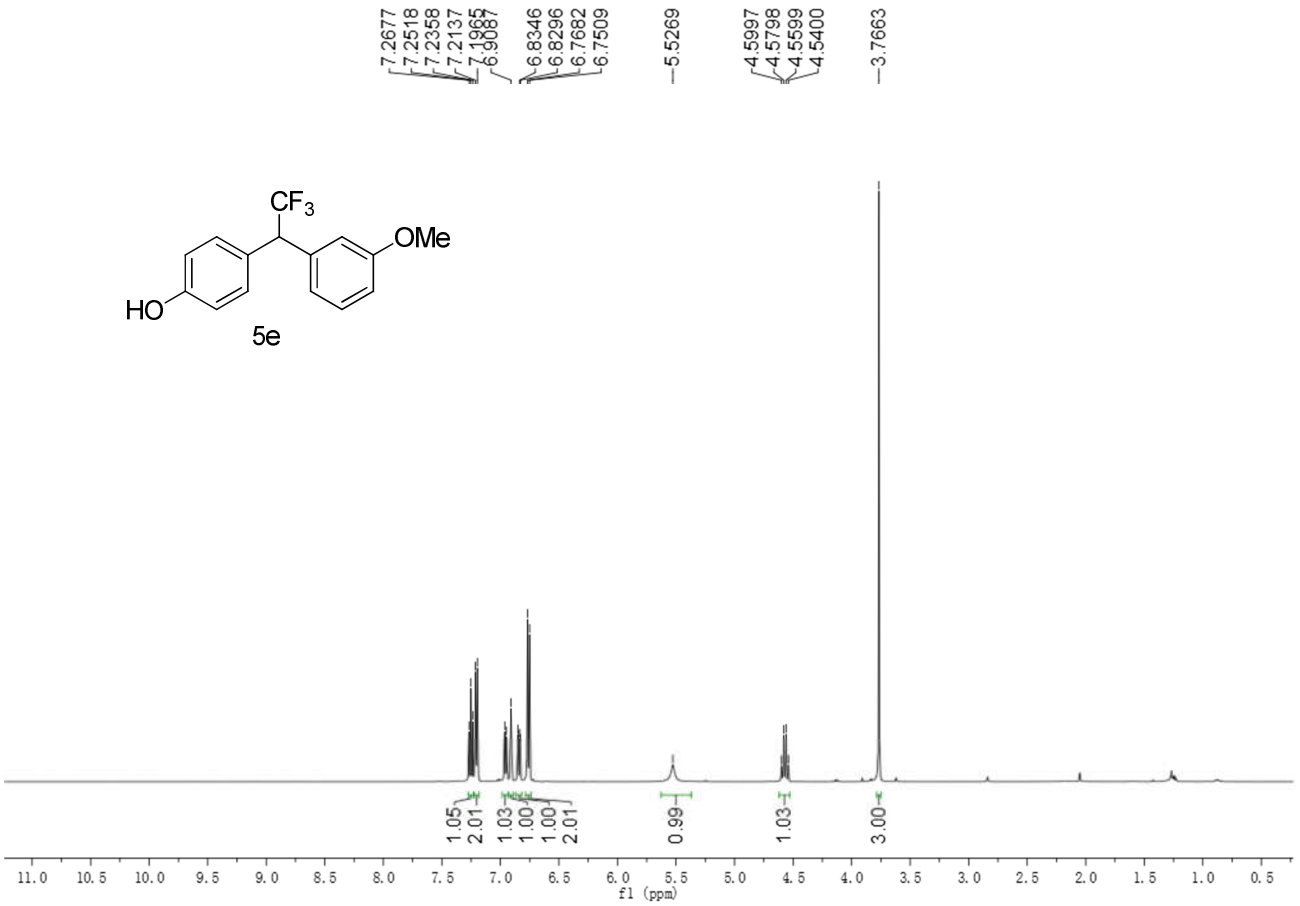

CF3
HO
Cl

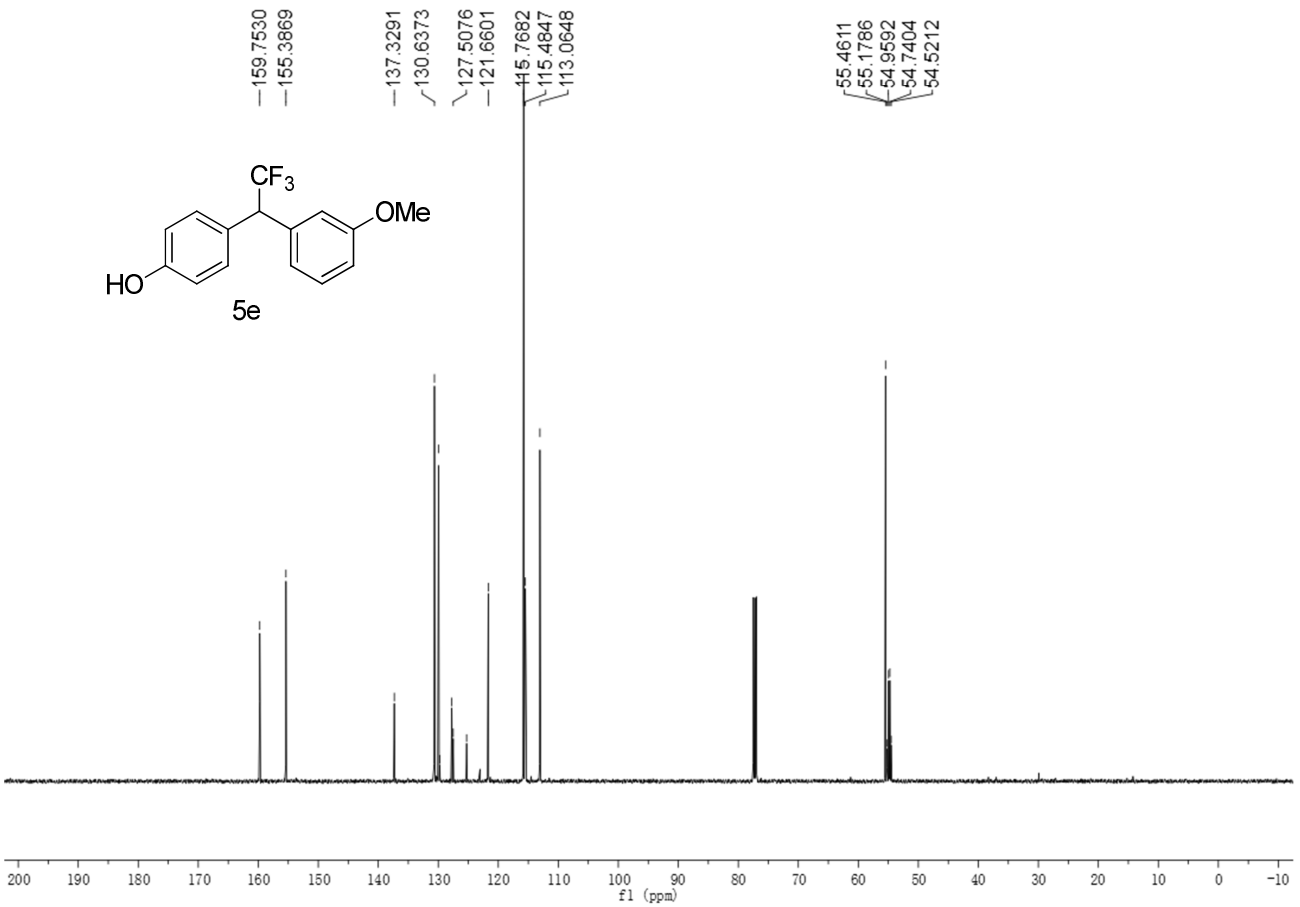
5d


3.96
1.98
2.00
0.99
1.02
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


155.5532
130.6107
129.1112
127.4295
127.3319
125.1019
122.8719
115.9008
54.6586
54.4372
54.2161
53.9948
CF3
HO
Cl
5d
f1 (ppm)


-66.2569
CF3
HO
Cl
5d
f1 (ppm)


7.2677
7.2518
7.2358
7.2137
7.1965
6.9087
6.8346
6.8296
6.7682
6.7509
5.5269
4.5997
4.5798
4.5599
4.5400
3.7663
CF3
OMe
HO
5e
1.05
2.01
1.03
1.00
1.00
2.01
0.99
1.03
3.00
f1 (ppm)


159.7530
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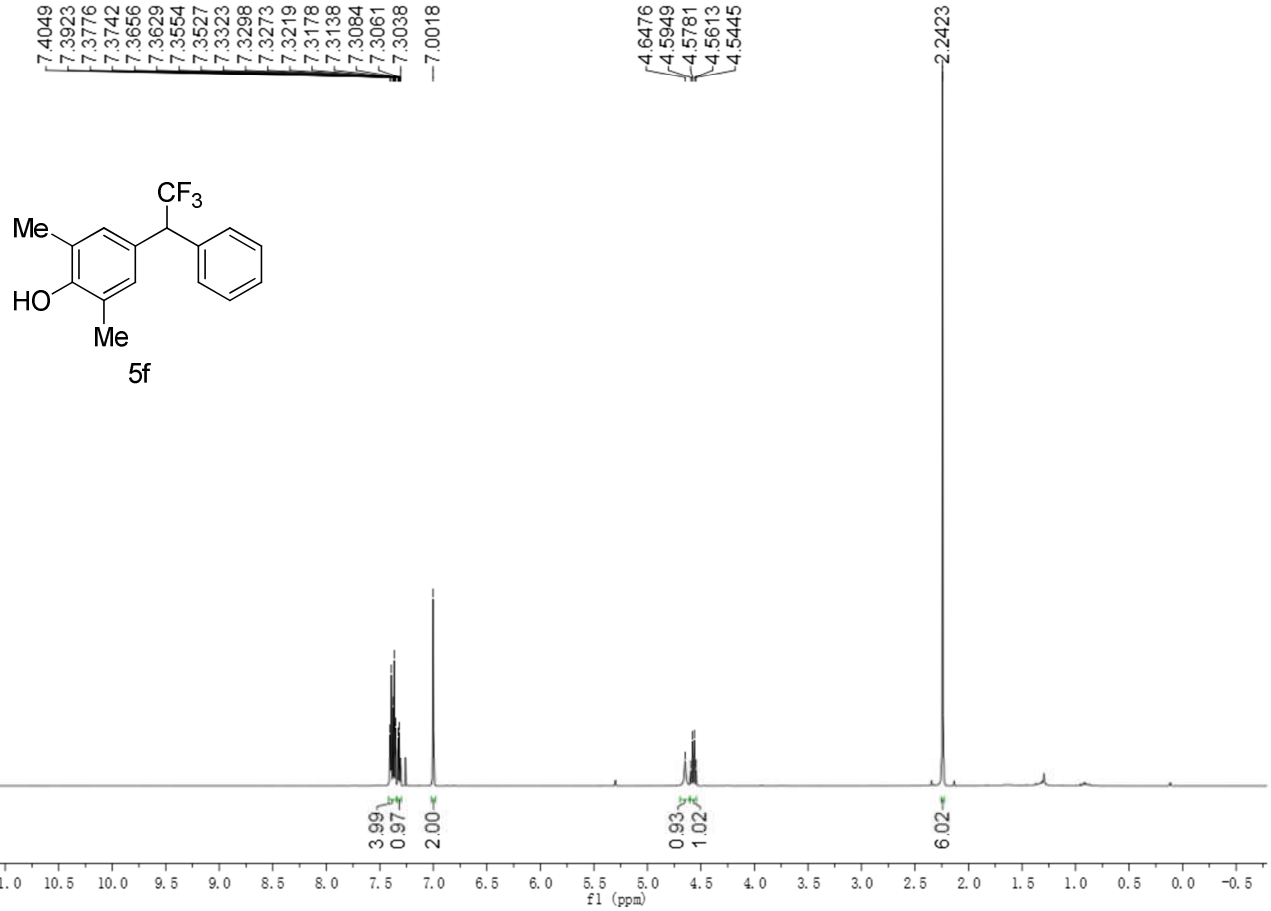
137.3291
130.6373
127.5076
121.6601
115.7682
115.4847
113.0648
55.4611
55.1786
54.9592
54.7404
54.5212
CF3
OMe
HO
5e
f1 (ppm)

CF3
OMe
HO

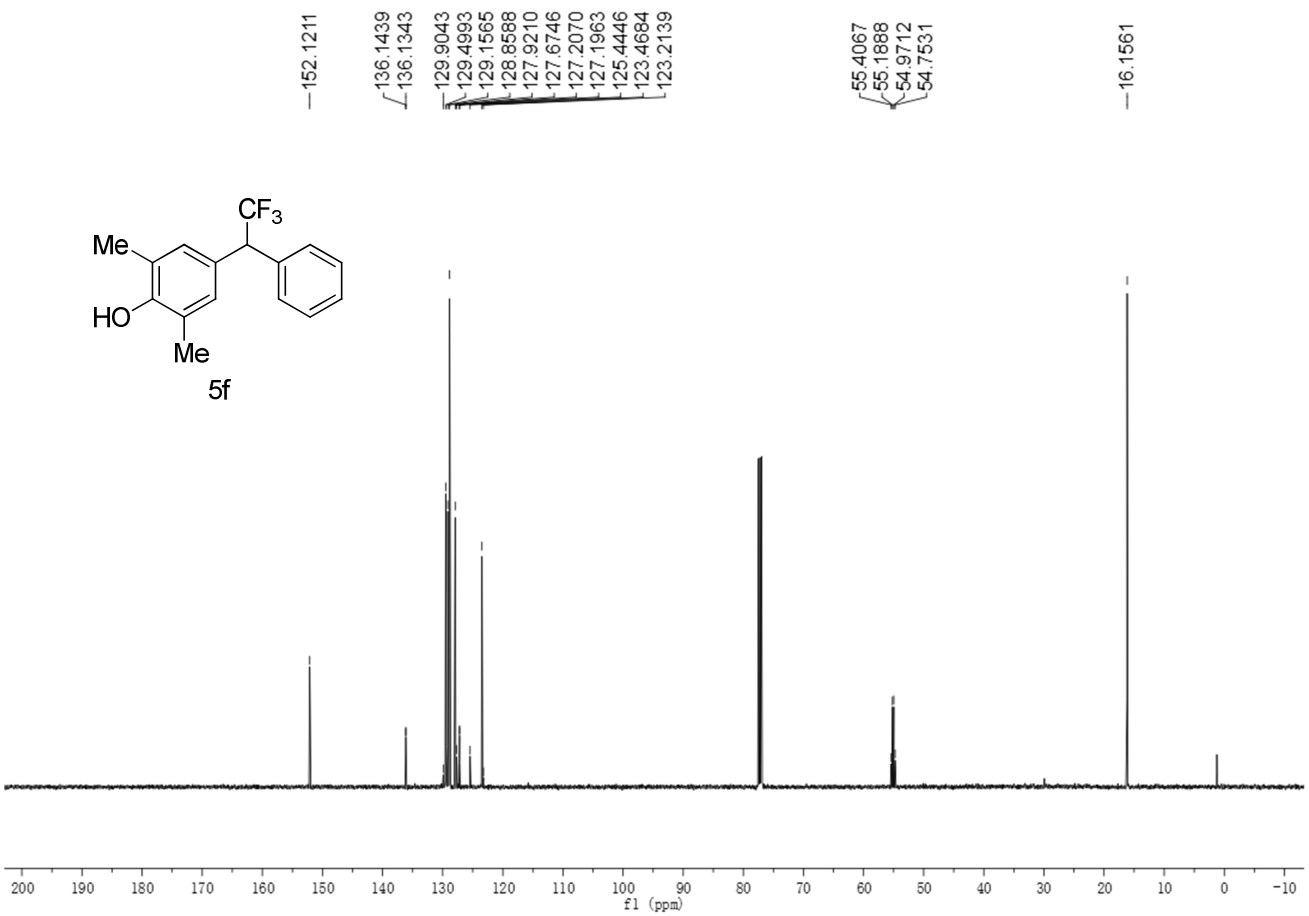
5e


-65.9589
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110
f1 (ppm)

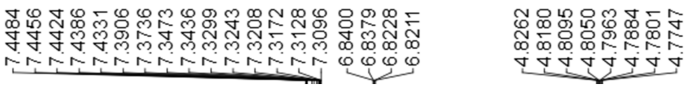

7.4049
7.3923
7.3776
7.3742
7.3656
7.3629
7.3554
7.3527
7.3323
7.3298
7.3273
7.3219
7.3178
7.3138
7.3084
7.3061
7.3038
7.0018
4.6476
4.5949
4.5781
4.5613
4.5445
2.2423
3.99
0.97
2.00
0.93
1.02
6.02
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

CF3
Me
HO
Me

5f


152.1211
136.1439
136.1343
129.9043
129.4993
129.1565
128.8588
127.9210
127.6746
127.2070
127.1963
125.4446
123.4684
123.2139
55.4067
55.1888
54.9712
54.7531
16.1561
CF3
Me
HO
Me
5f
f1 (ppm)


65.9493
CF3
Me
HO
Me
5f
f1 (ppm)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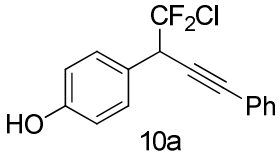
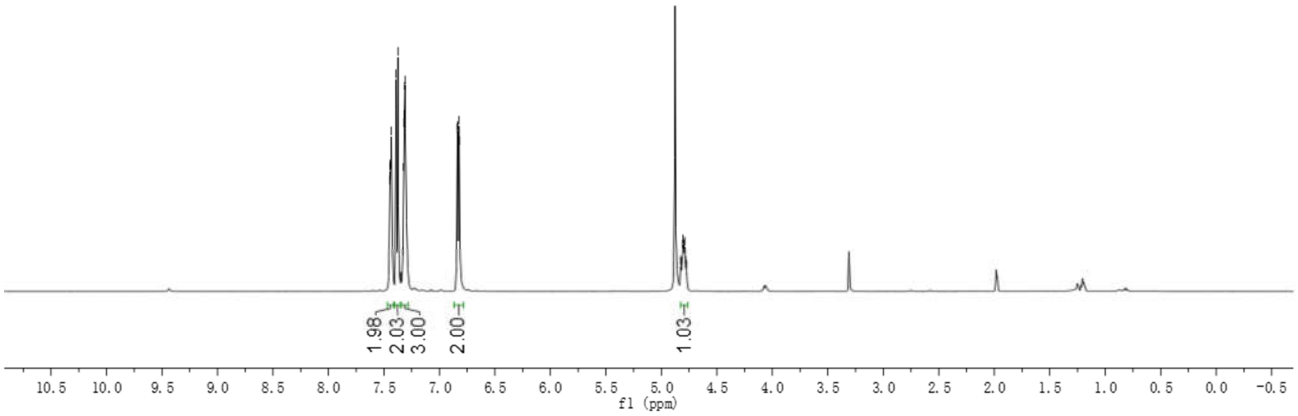
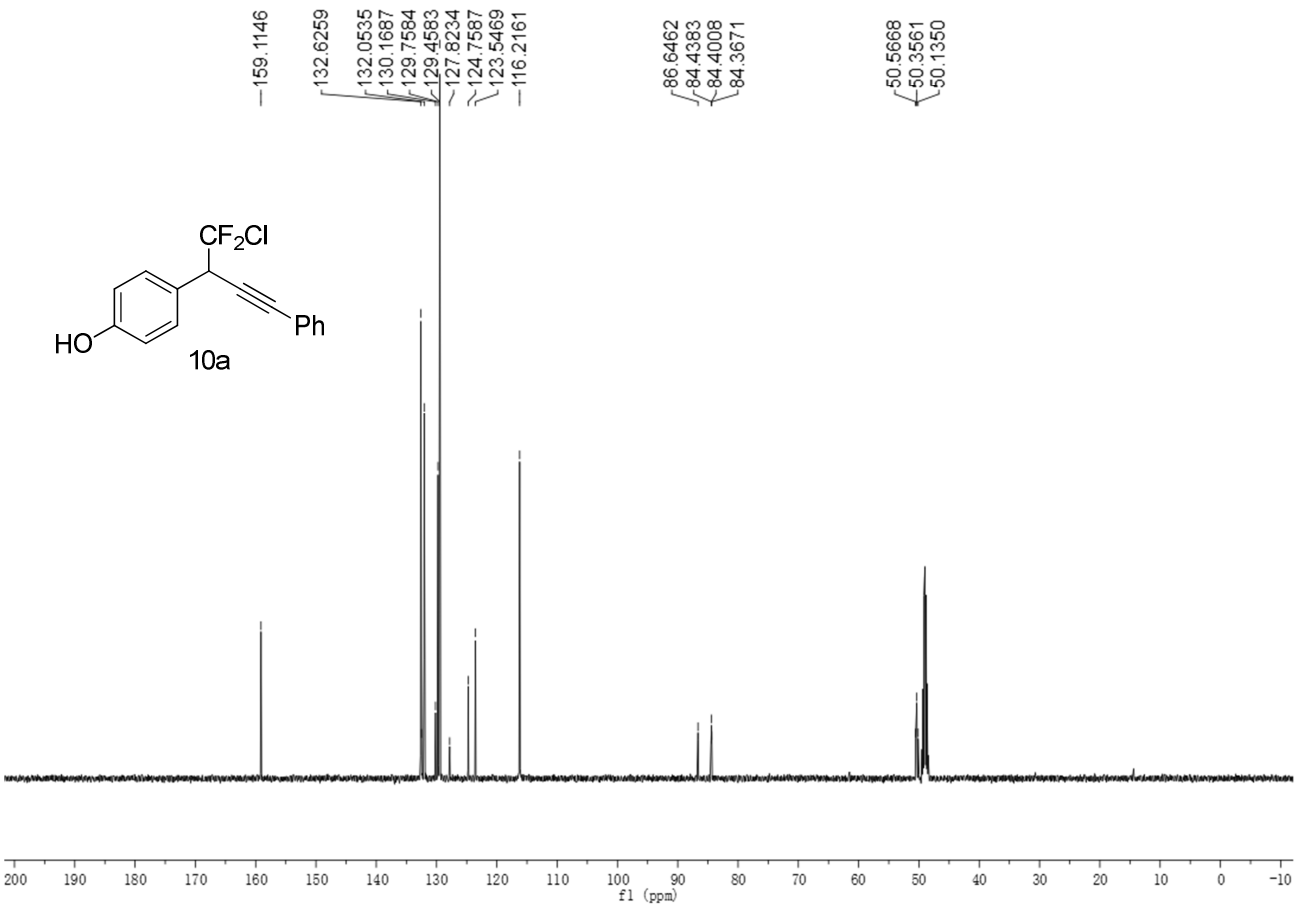
7.4456
7.4424
7.4386
7.4331
7.3906
7.3736
7.3473
7.3436
7.3299
7.3243
7.3208
7.3172
7.3128
7.3096
6.8400
6.8379
6.8228
6.8211
4.8262
4.8180
4.8095
4.8050
4.7963
4.7884
4.7801
4.7747

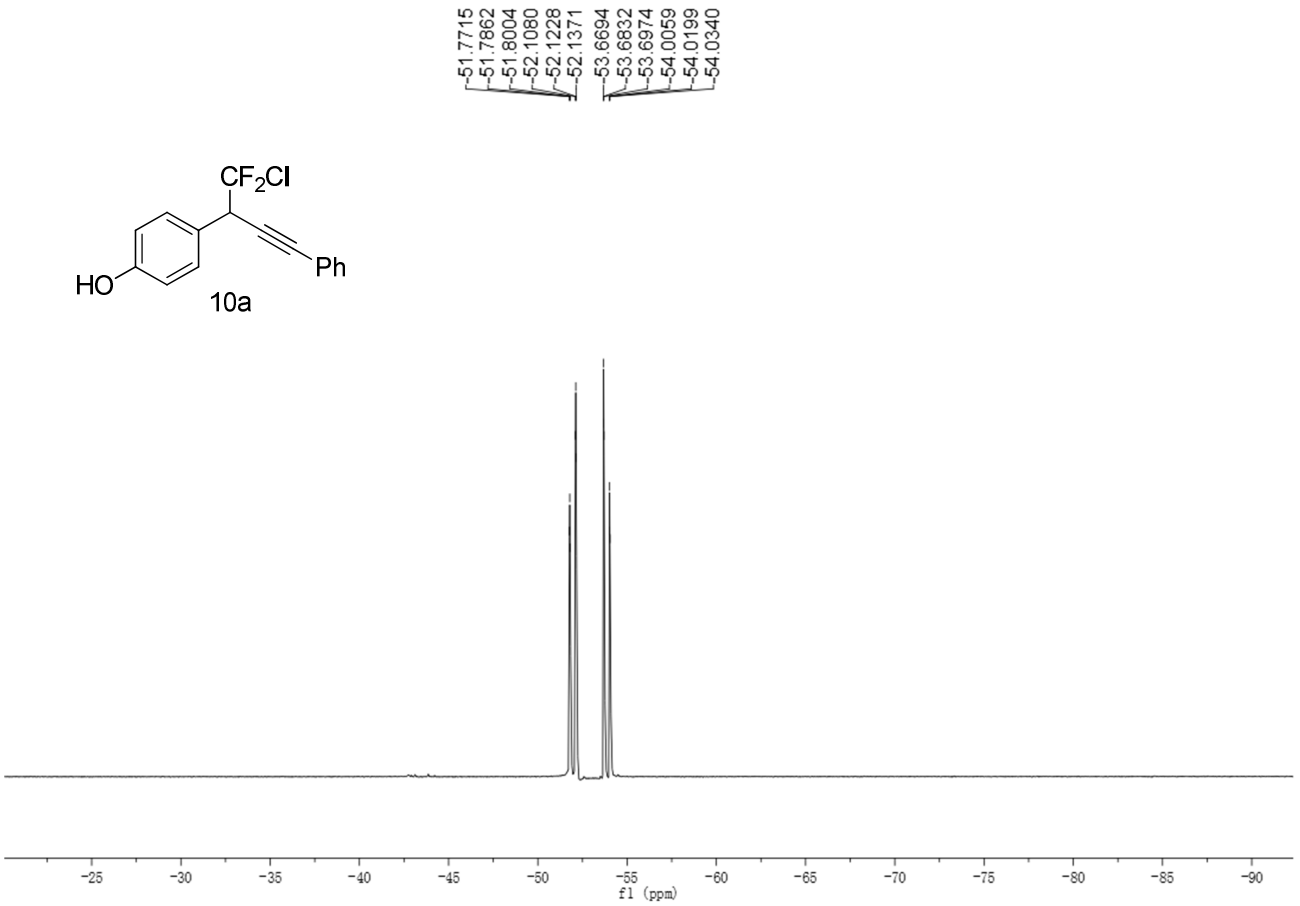

CF2Cl
HO
Ph

10a


1.98
2.03
3.00
2.00
1.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


159.1146
132.6259
132.0535
130.1687
129.7584
129.4583
127.8234
124.7587
123.5469
116.2161
86.6462
84.4383
84.4008
84.3671
50.5668
50.3561
50.1350
CF2Cl
HO
Ph
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

10a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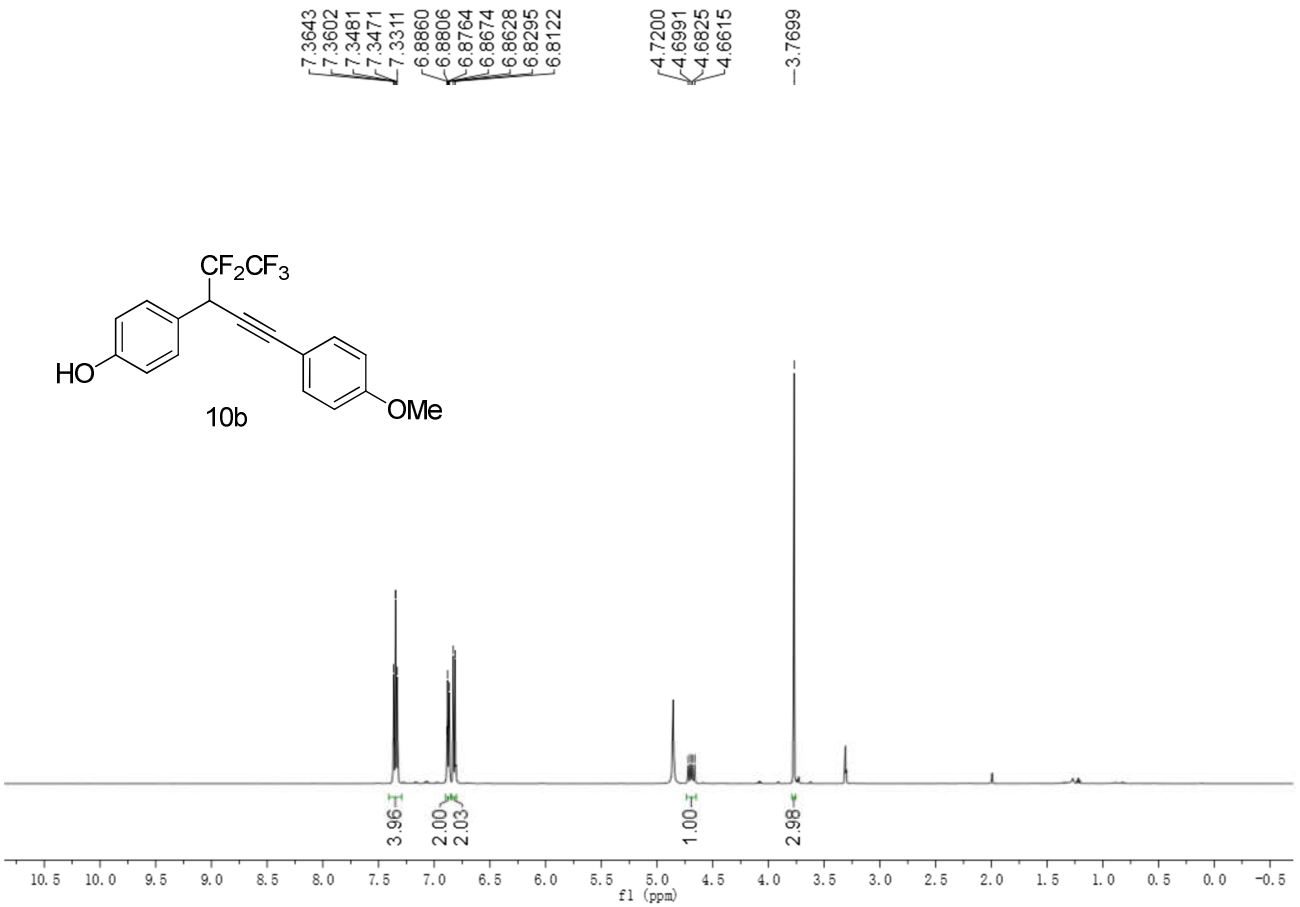
52.1228
52.1371
53.6694
53.6832
53.6974
54.0059
54.0199
54.0340
CF2Cl
HO
Ph
10a
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
f1 (ppm)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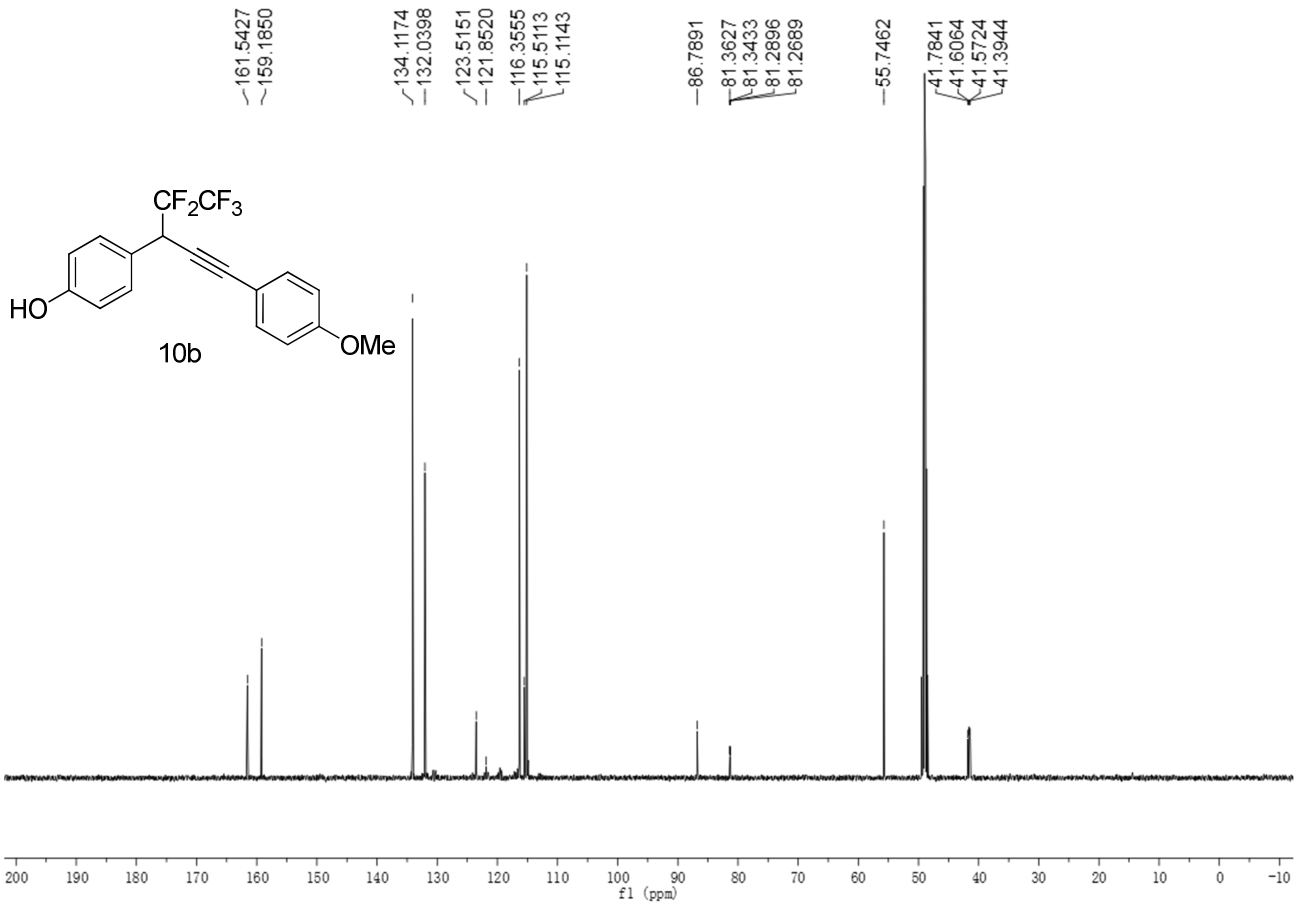
7.3602
7.3481
7.3471
7.3311
6.8860
6.8806
6.8764
6.8674
6.8628
6.8295
6.8122
4.7200
4.6991
4.6825
4.6615
3.7699
CF2CF3
HO
OMe
10b
3.96
2.00
2.03
1.00
2.98
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


161.5427
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134.1174
132.0398
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121.8520
116.3555
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115.1143
86.7891
81.3627
81.3433
81.2896
81.2689
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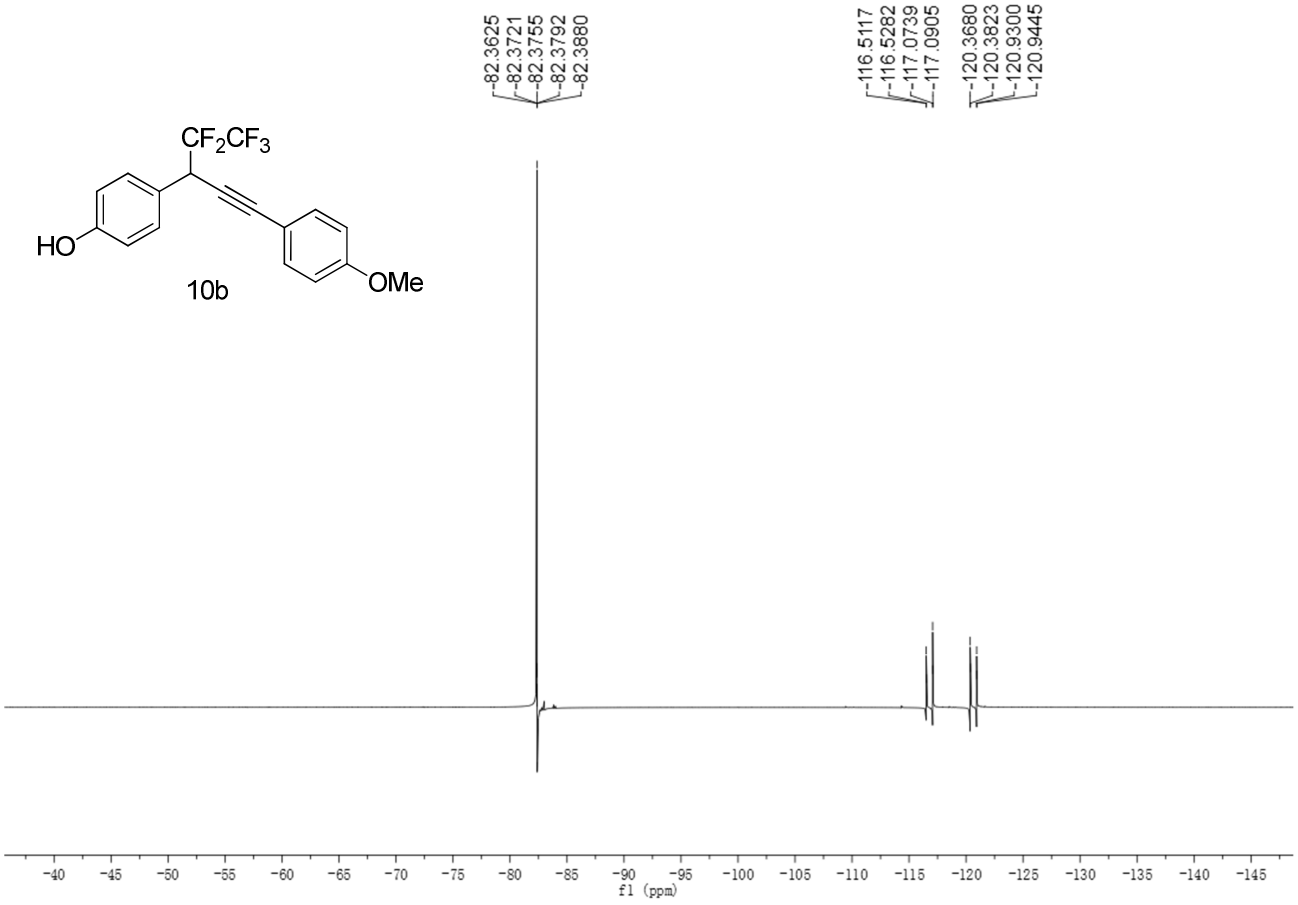
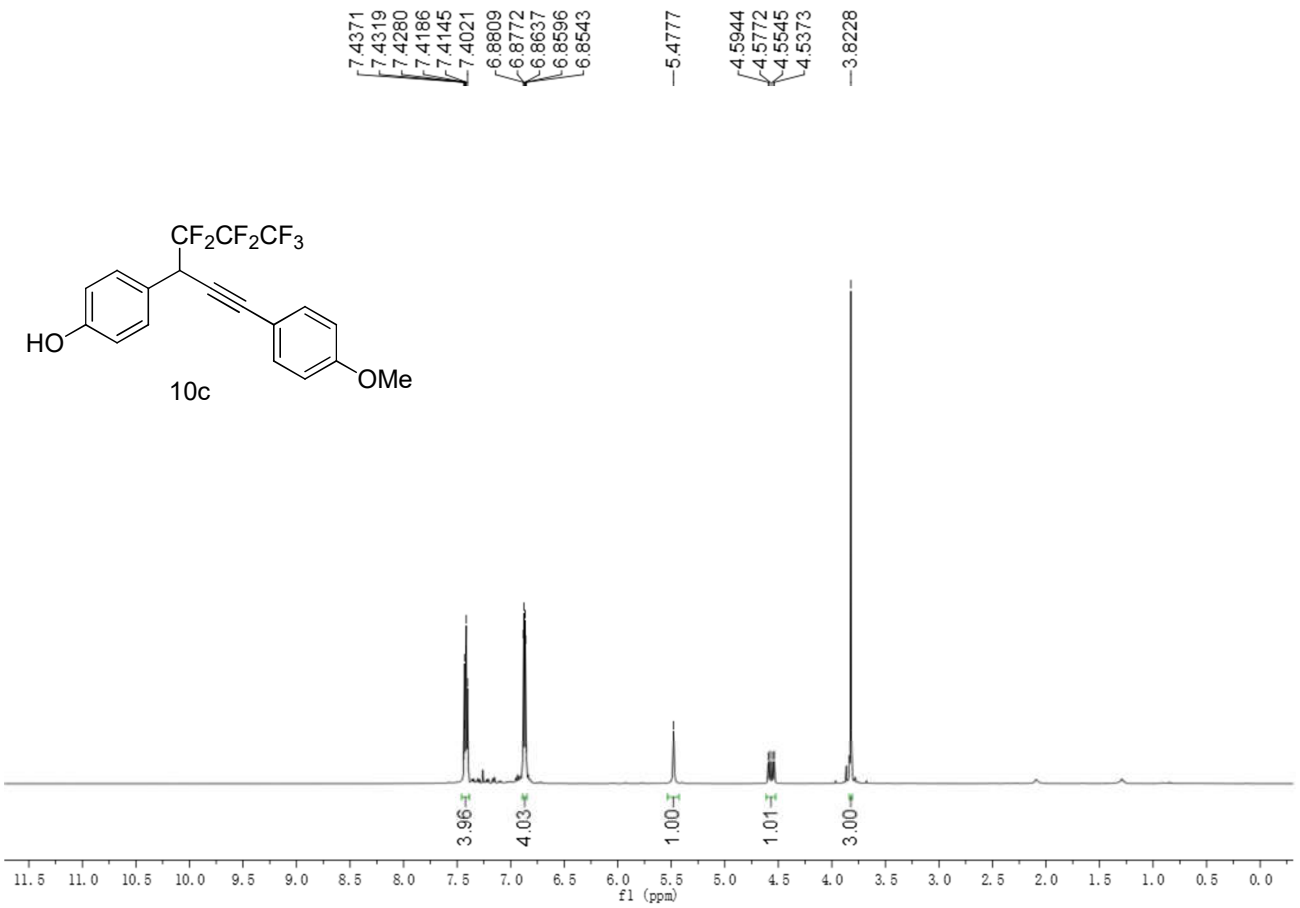
41.7841
41.6064
41.5724
41.3944
CF2CF3
HO
OMe
10b
f1 (ppm)


82.3625
82.3721
82.3755
82.3792
82.3880
116.5117
116.5282
117.0739
117.0905
120.3680
120.3823
120.9300
120.9445
CF2CF3
HO
OMe
10b
f1 (ppm)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7.4186
7.4145
7.4021
6.8809
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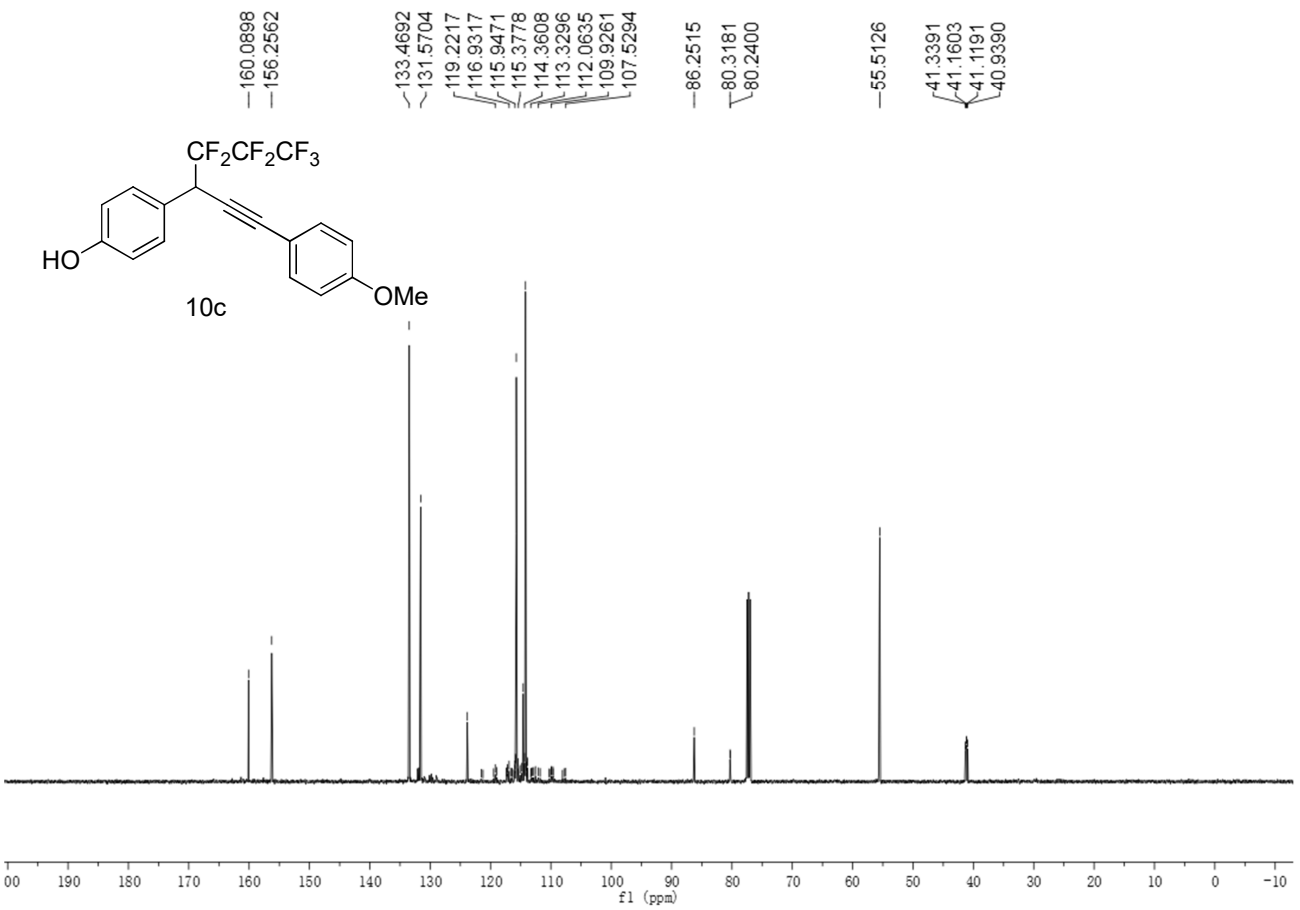
6.8637
6.8596
6.8543
5.4777
4.5944
4.5772
4.5545
4.5373
3.8228
CF2CF2CF3
HO
OMe
10c
3.96
4.03
1.00
1.01
3.00
f1 (ppm)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133.4692
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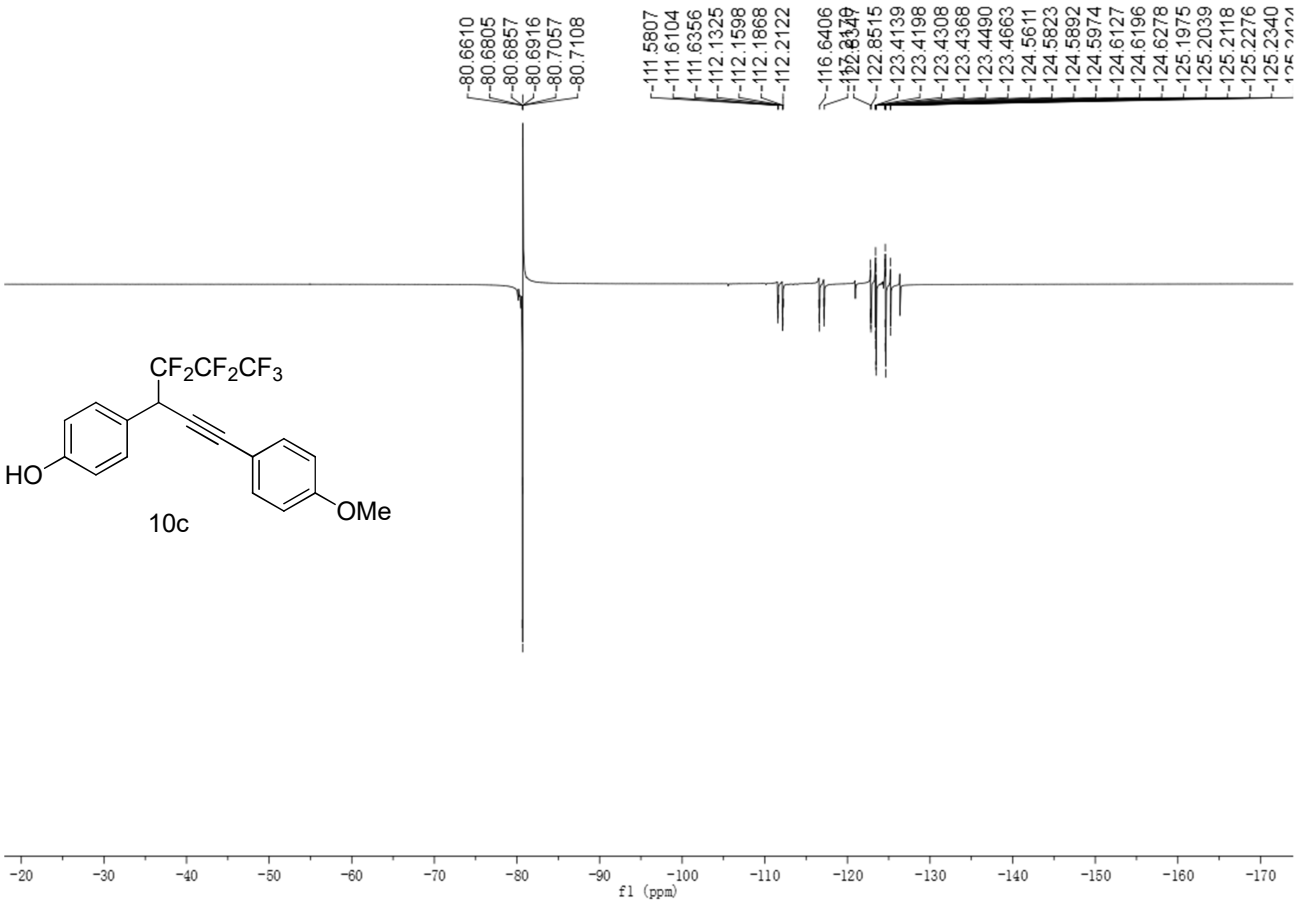
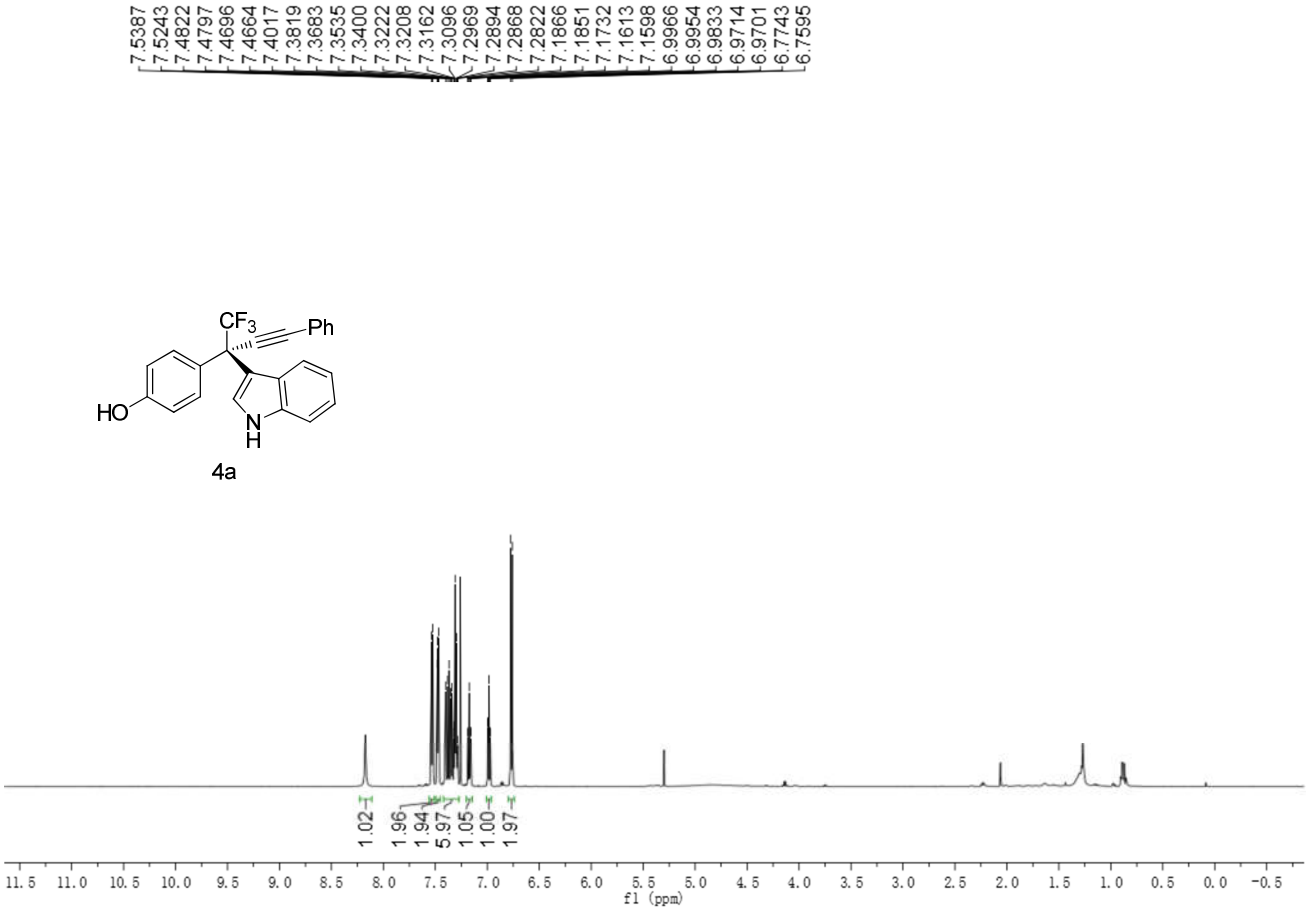
112.0635
109.9261
107.5294
86.2515
80.3181
80.2400
55.5126
41.3391
41.1603
41.1191
40.9390
CF2CF2CF3
HO
OMe
10c
f1 (ppm)


-80.6610
-80.6805
-80.6857
-80.6916
-80.7057
-80.7108
-111.5807
-111.6104
-111.6356
-112.1325
-112.1598
-112.1868
-112.2122
-116.6406
-122.8515
-123.4139
-123.4198
-123.4308
-123.4368
-123.4490
-123.4663
-124.5611
-124.5823
-124.5892
-124.5974
-124.6127
-124.6196
-124.6278
-125.1975
-125.2039
-125.2118
-125.2276
-125.2340
CF2CF2CF3
HO
OMe
10c
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
f1 (ppm)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7.4822
7.4797
7.4696
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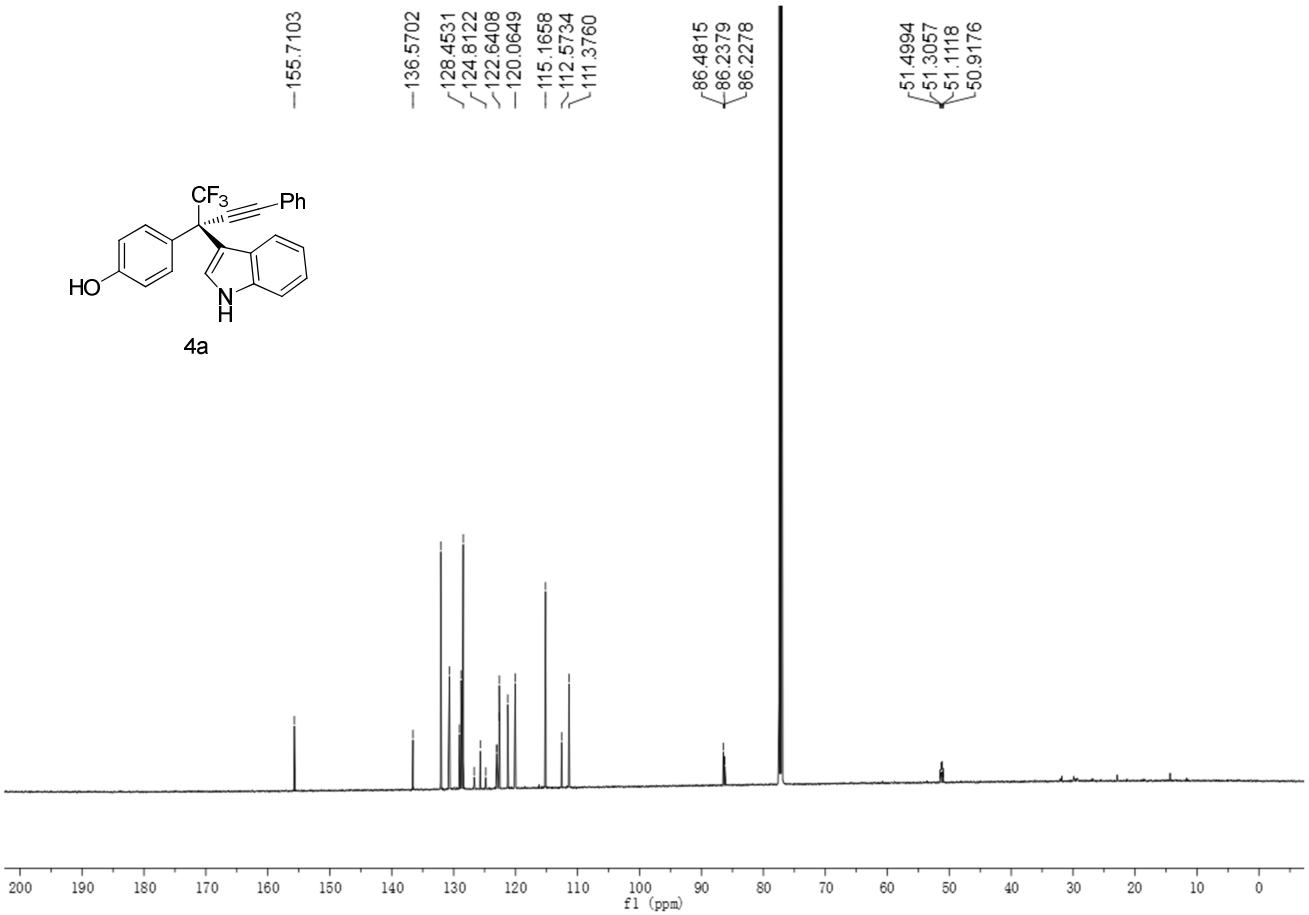
7.4017
7.3819
7.3683
7.3535
7.3400
7.3222
7.3208
7.3162
7.3096
7.2969
7.2894
7.2868
7.2822
7.1866
7.1851
7.1732
7.1613
7.1598
6.9966
6.9954
6.9833
6.9714
6.9701
6.7743
6.7595
CF3
Ph
HO
N
H
4a
1.02
1.96
1.94
5.97
1.05
1.00
1.97
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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122.6408
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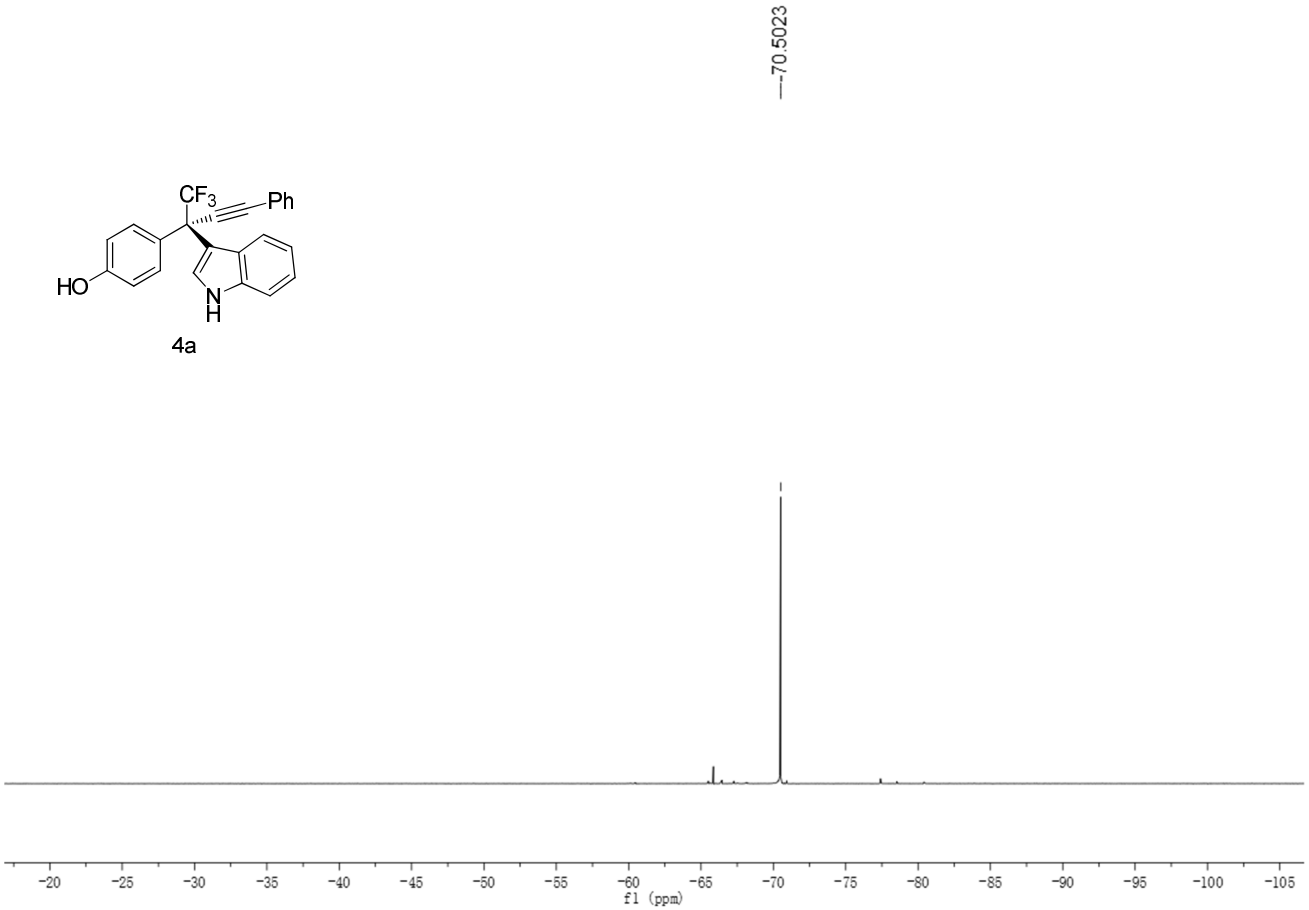
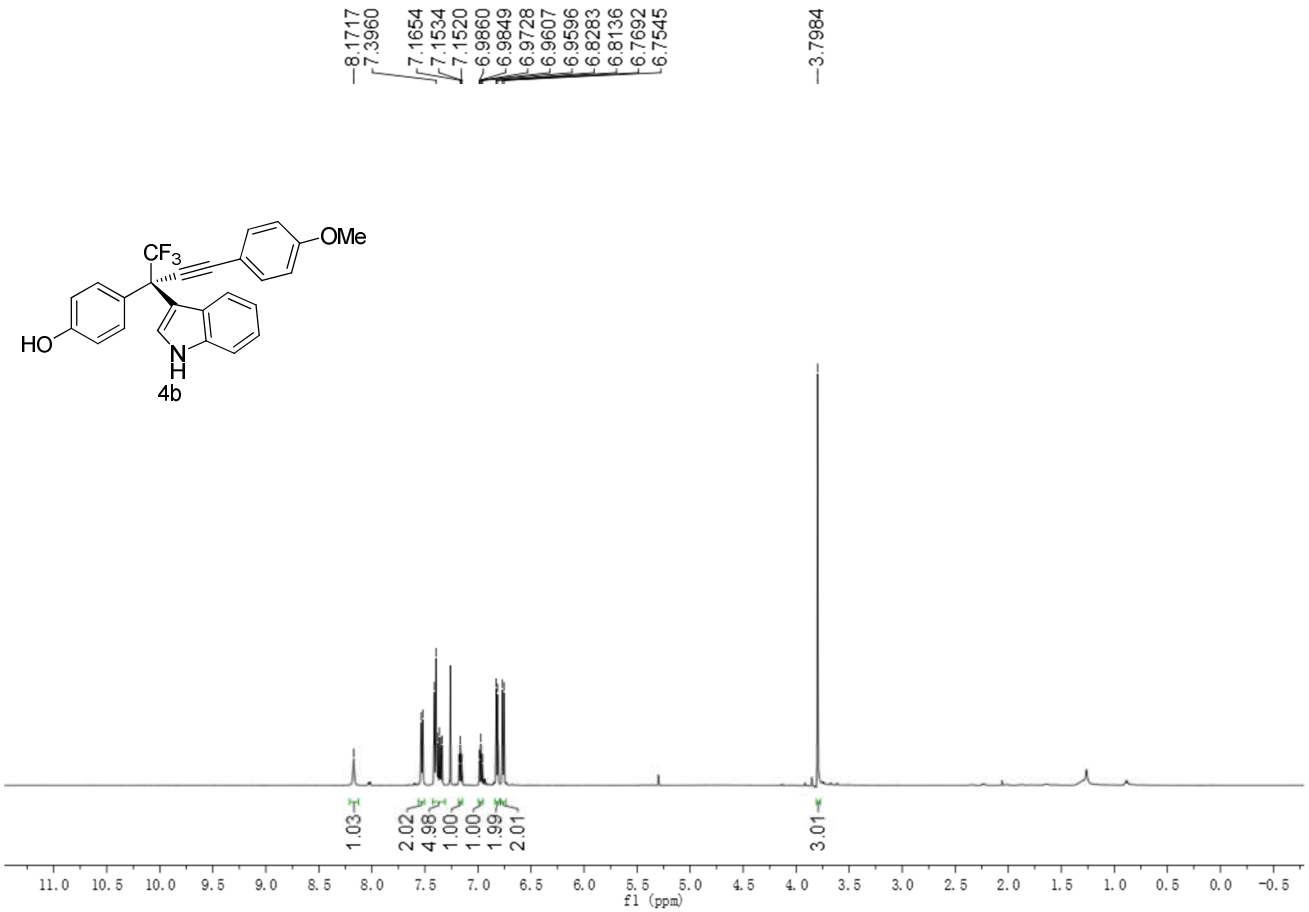
115.1658
112.5734
111.3760
86.4815
86.2379
86.2278
51.4994
51.3057
51.1118
50.9176
CF3
Ph
HO
N
H
4a
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


70.5023
CF3
Ph
HO
N
H
4a
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105
f1 (ppm)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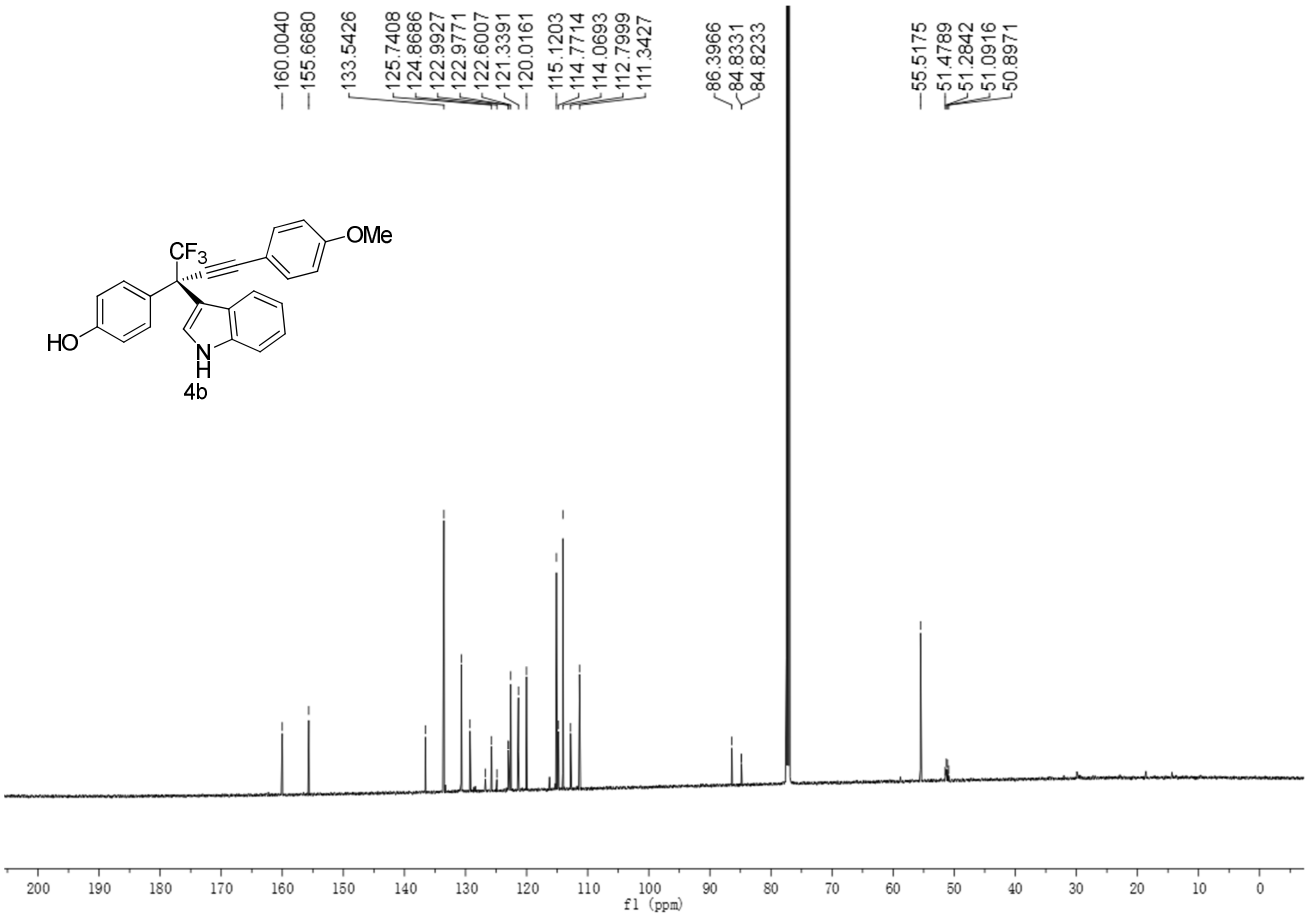
7.3960
7.1654
7.1534
7.1520
6.9860
6.9849
6.9728
6.9607
6.9596
6.8283
6.8136
6.7692
6.7545
3.7984
CF3
OMe
HO
N
H
4b
1.03
2.02
4.98
1.00
1.00
1.99
2.01
3.01
f1 (ppm)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122.9771
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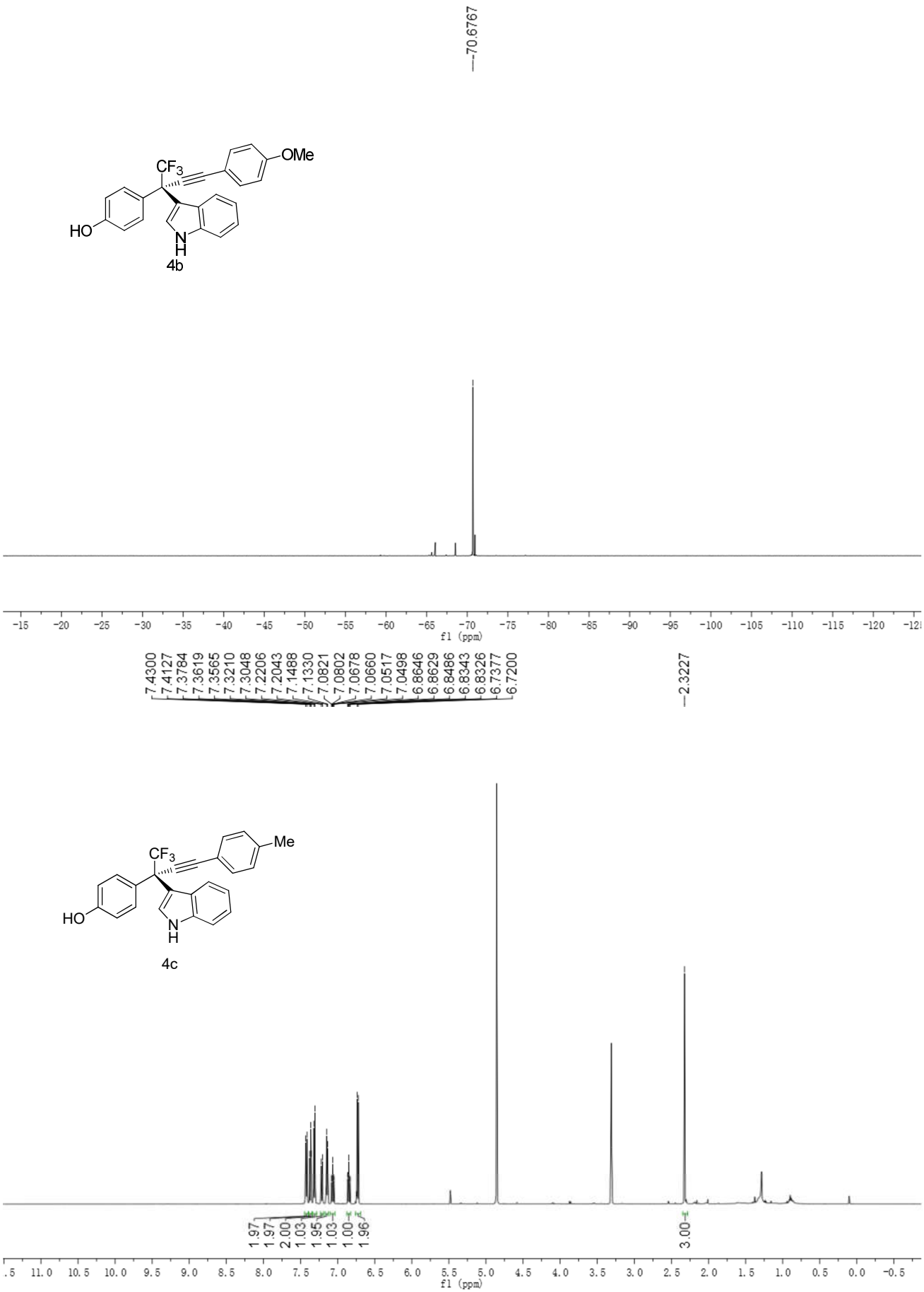
121.3391
120.0161
115.1203
114.7714
114.0693
112.7999
111.3427
86.3966
84.8331
84.8233
55.5175
51.4789
51.2842
51.0916
50.8971
CF3
OMe
HO
N
H
4b
f1 (ppm)


-70.6767
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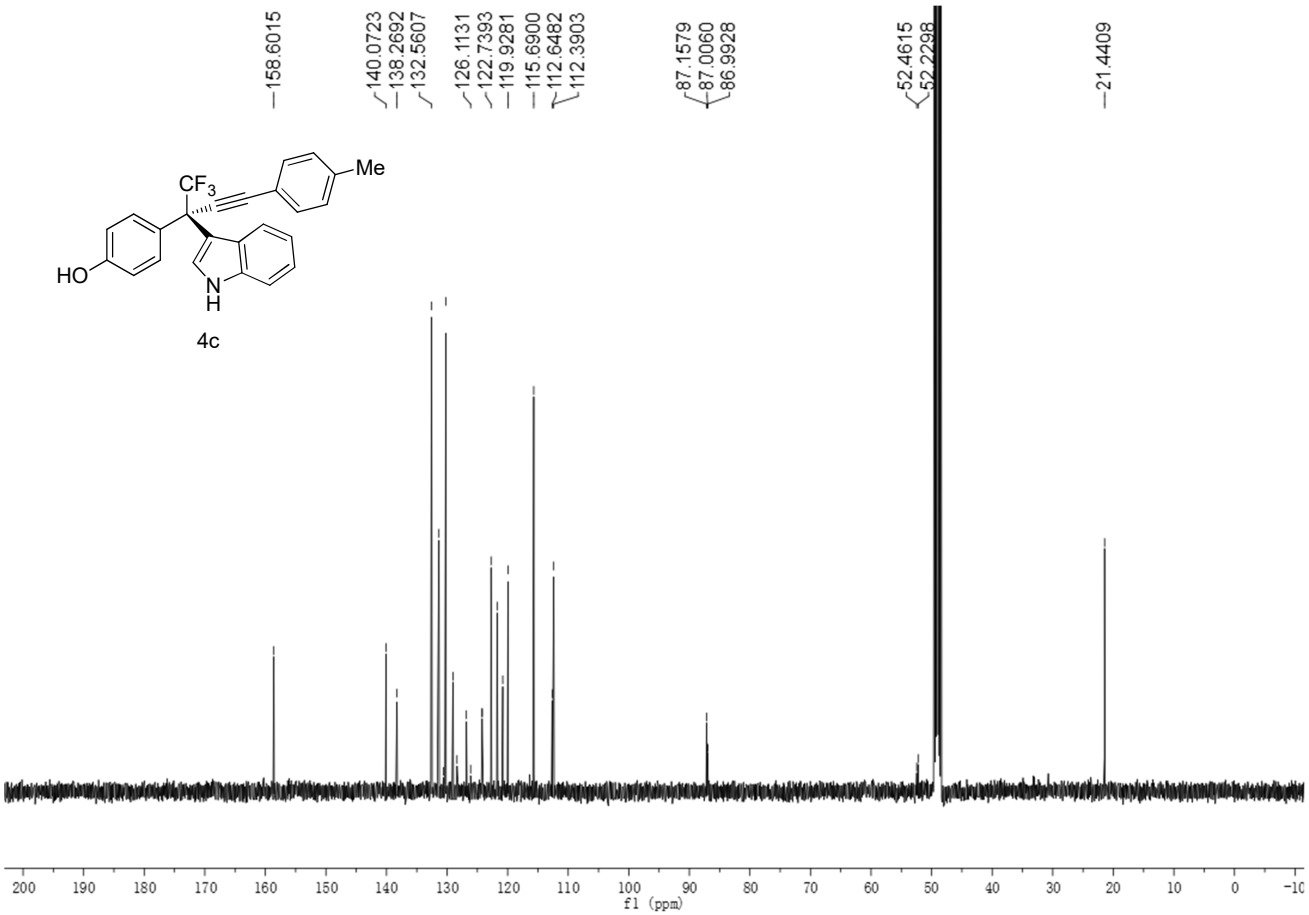
OMe
HO
N
H
4b
-15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120
f1 (ppm)
7.4300
7.4127
7.3784
7.3619
7.3565
7.3210
7.3048
7.2206
7.2043
7.1488
7.1330
7.0821
7.0802
7.0678
7.0660
7.0517
7.0498
6.8646
6.8629
6.8486
6.8343
6.8326
6.7377
6.7200
-2.3227
Me
CF3
HO
N
H
4c
1.97
1.97
2.00
1.03
1.95
1.03
1.00
1.96
3.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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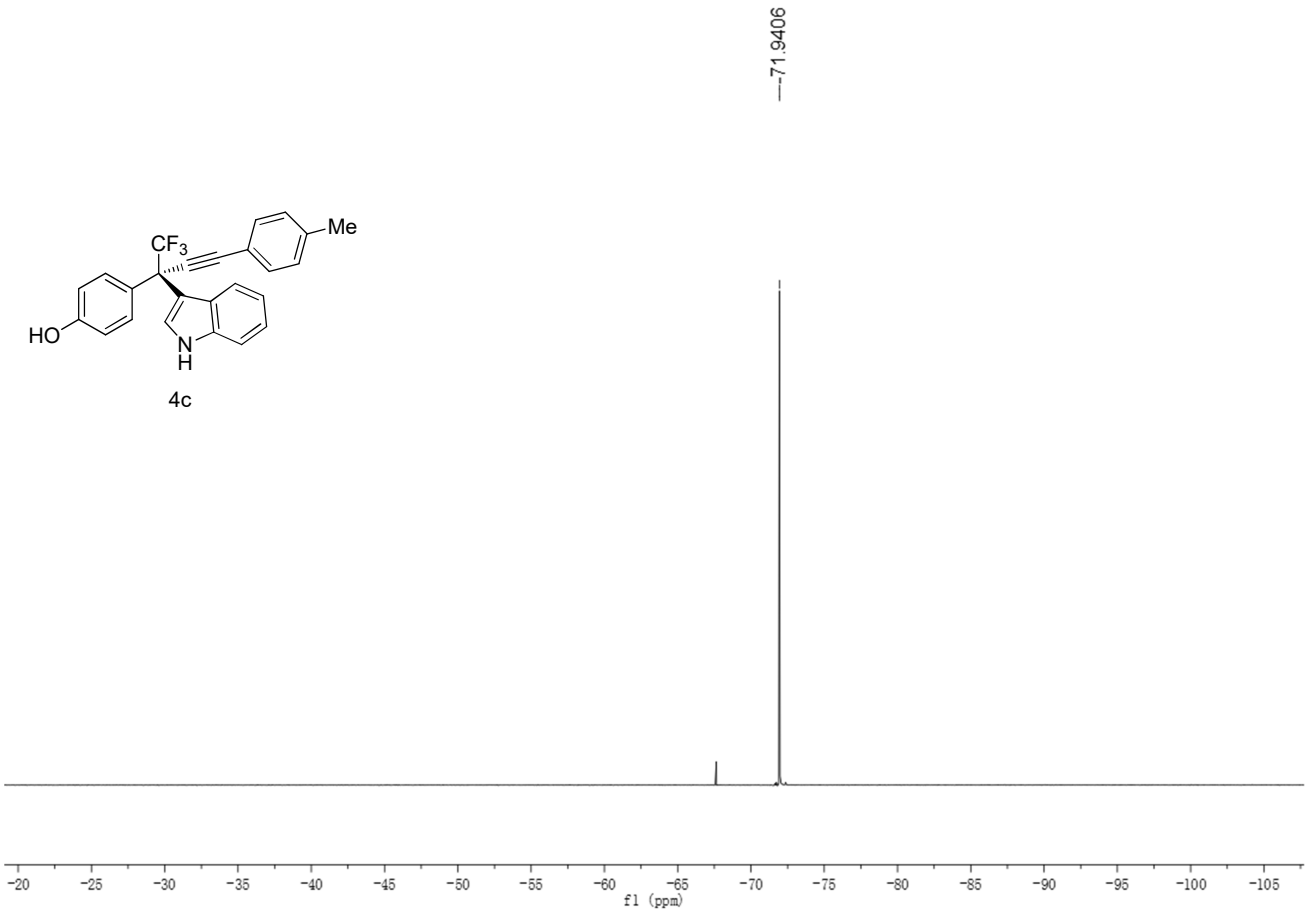
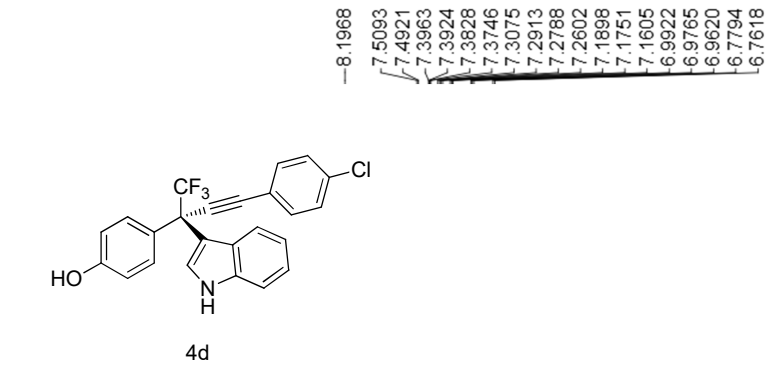
140.0723
138.2692
132.5607
126.1131
122.7393
119.9281
115.6900
112.6482
112.3903
87.1579
87.0060
86.9928
52.4615
52.2298
21.4409
CF3
Me
HO
N
H
4c
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-71.9406
CF3
Me
HO
N
H
4c
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105
f1 (ppm)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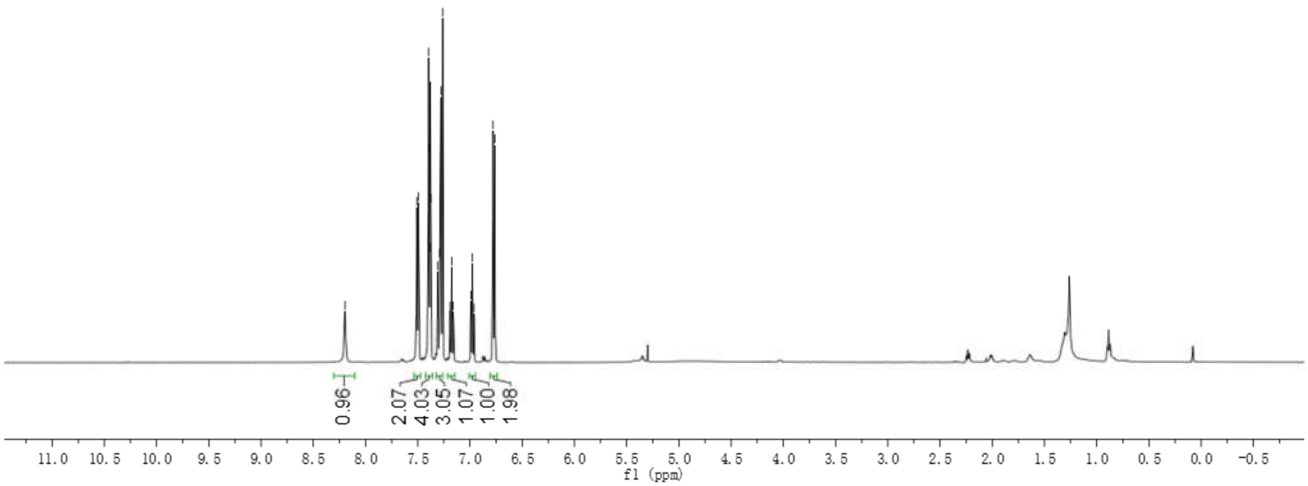
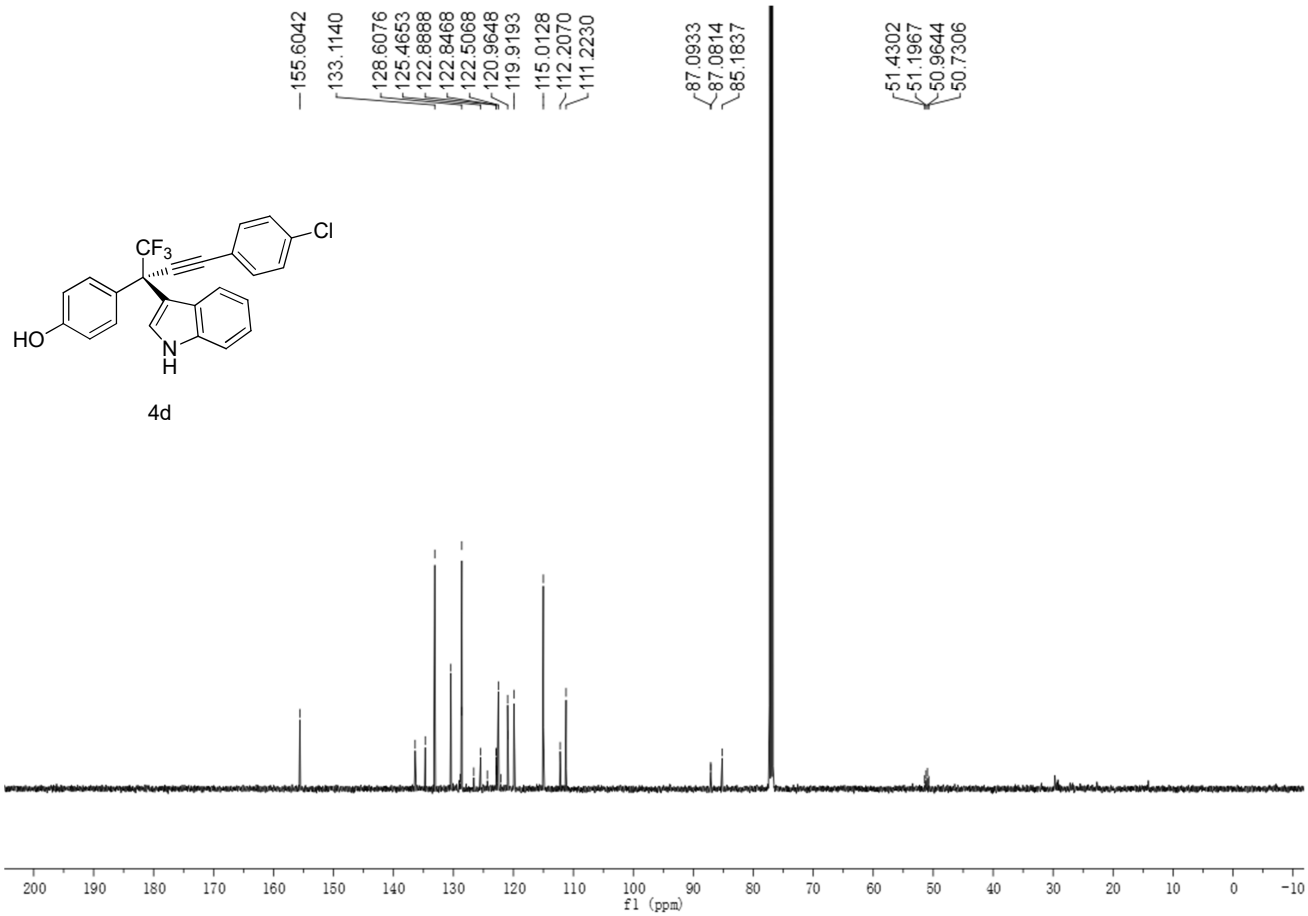
7.4921
7.3963
7.3924
7.3828
7.3746
7.3075
7.2913
7.2788
7.2602
7.1898
7.1751
7.1605
6.9922
6.9765
6.9620
6.7794
6.7618
CF3
Cl
HO
N
H

4d

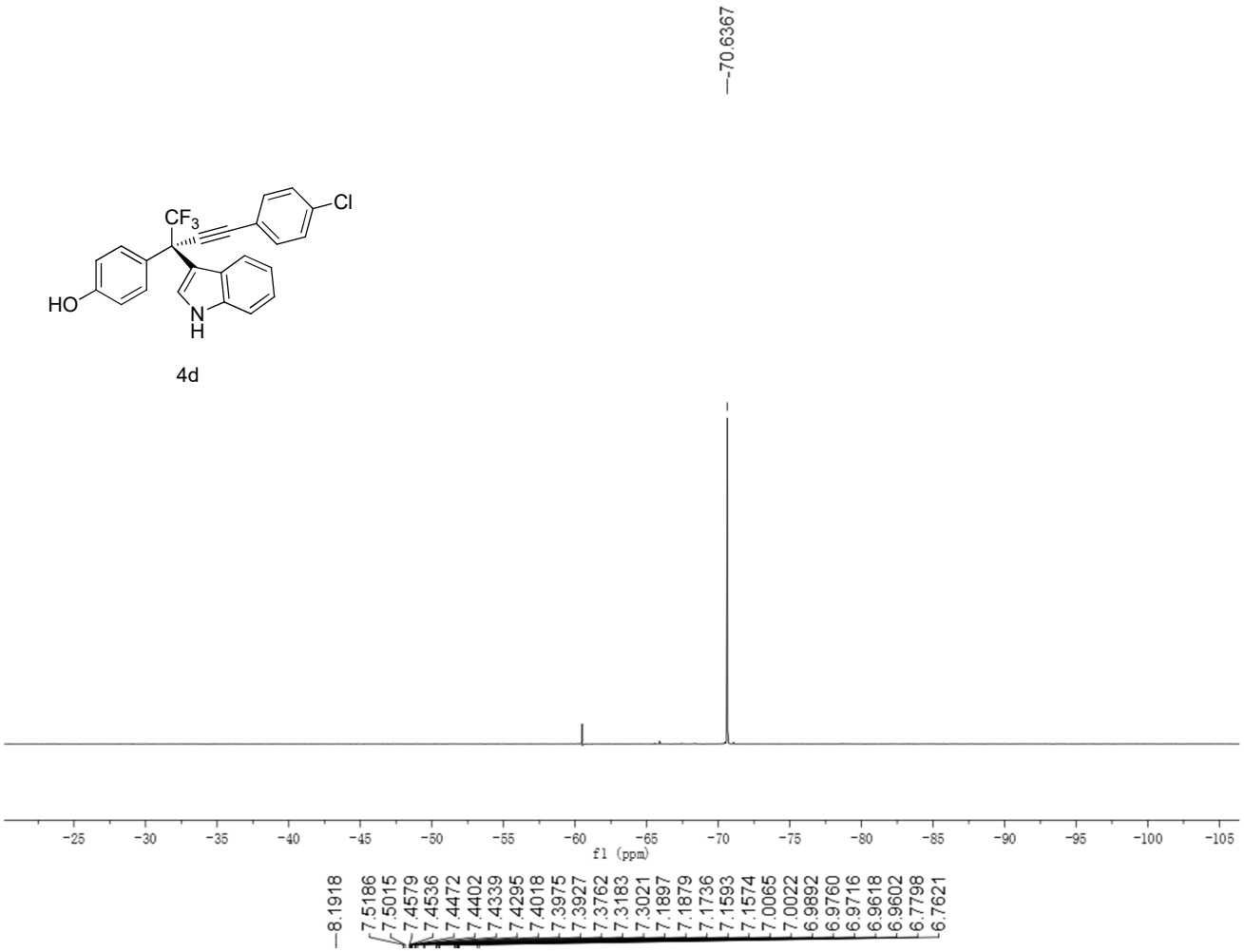

0.96
2.07
4.03
3.05
1.07
1.00
1.98
f1 (ppm)


155.6042
133.1140
128.6076
125.4653
122.8888
122.8468
122.5068
120.9648
119.9193
115.0128
112.2070
111.2230
87.0933
87.0814
85.1837
51.4302
51.1967
50.9644
50.7306
CF3
Cl
HO
N
H
f1 (ppm)

4d

CF3
Cl
HO
N
H

4d


-70.6367
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105
f1 (ppm)
8.1918
7.5186
7.5015
7.4579
7.4536
7.4472
7.4402
7.4339
7.4295
7.4018
7.3975
7.3927
7.3762
7.3183
7.3021
7.1897
7.1879
7.1736
7.1593
7.1574
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7.0022
6.9892
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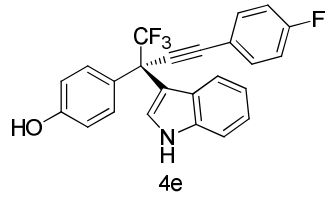
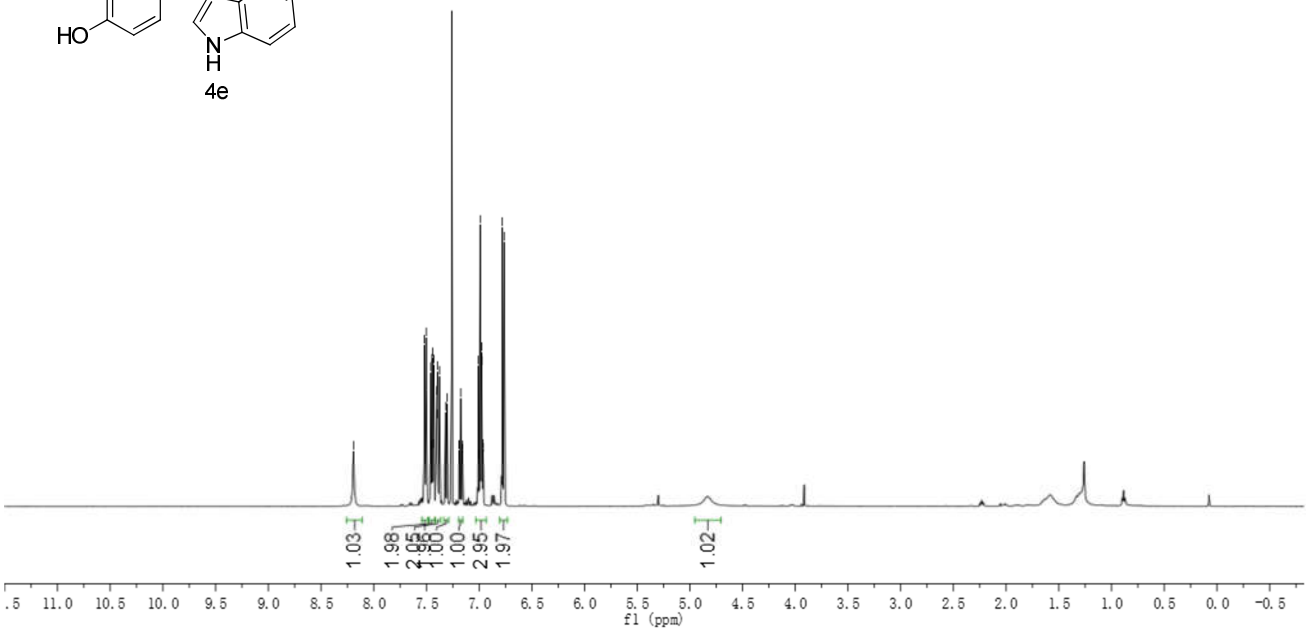
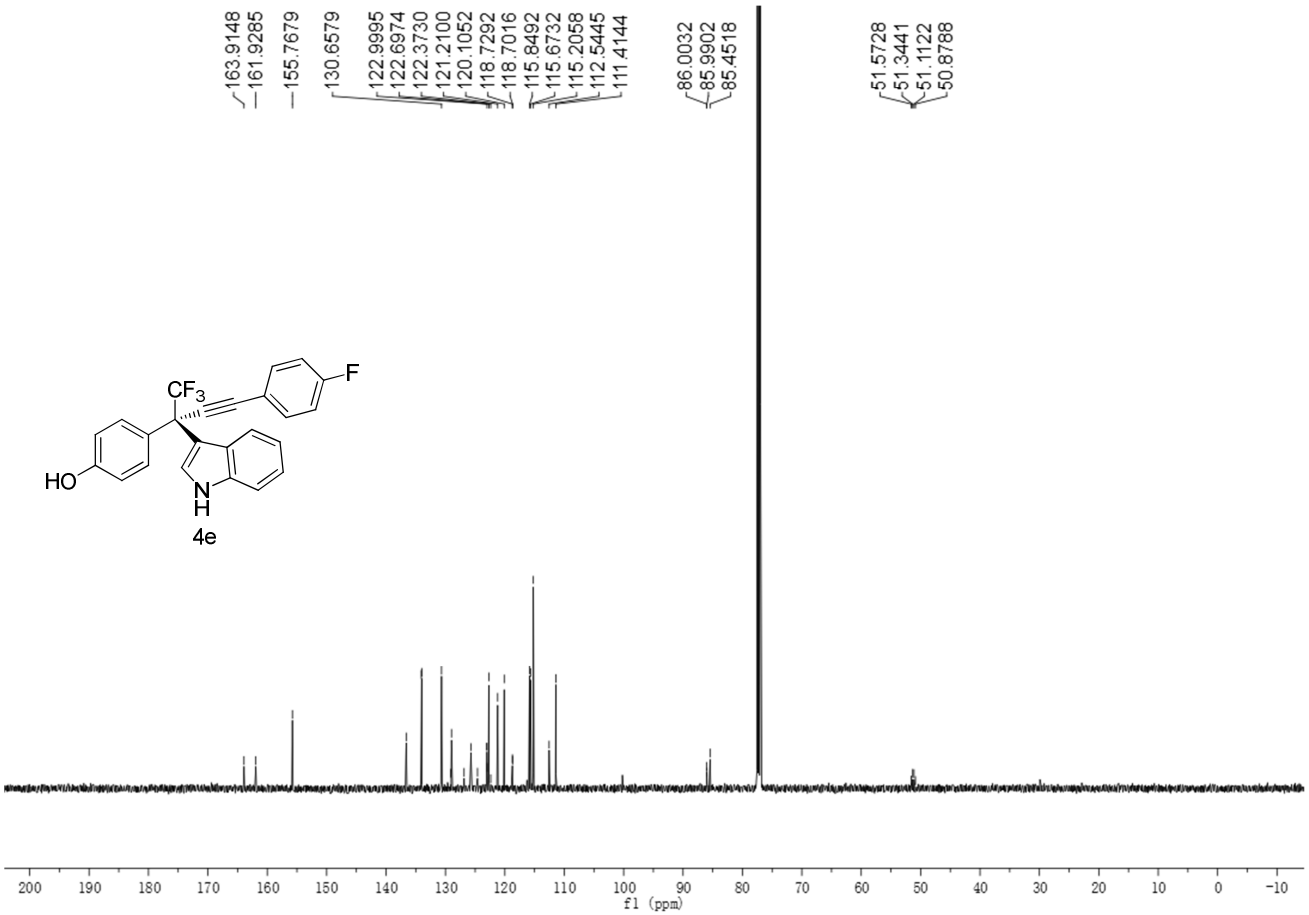
6.9716
6.9618
6.9602
6.7798
6.7621


CF3
F
HO
N
H

4e


1.03
1.98
2.05
1.96
1.00
2.95
1.97
1.02
.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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130.6579
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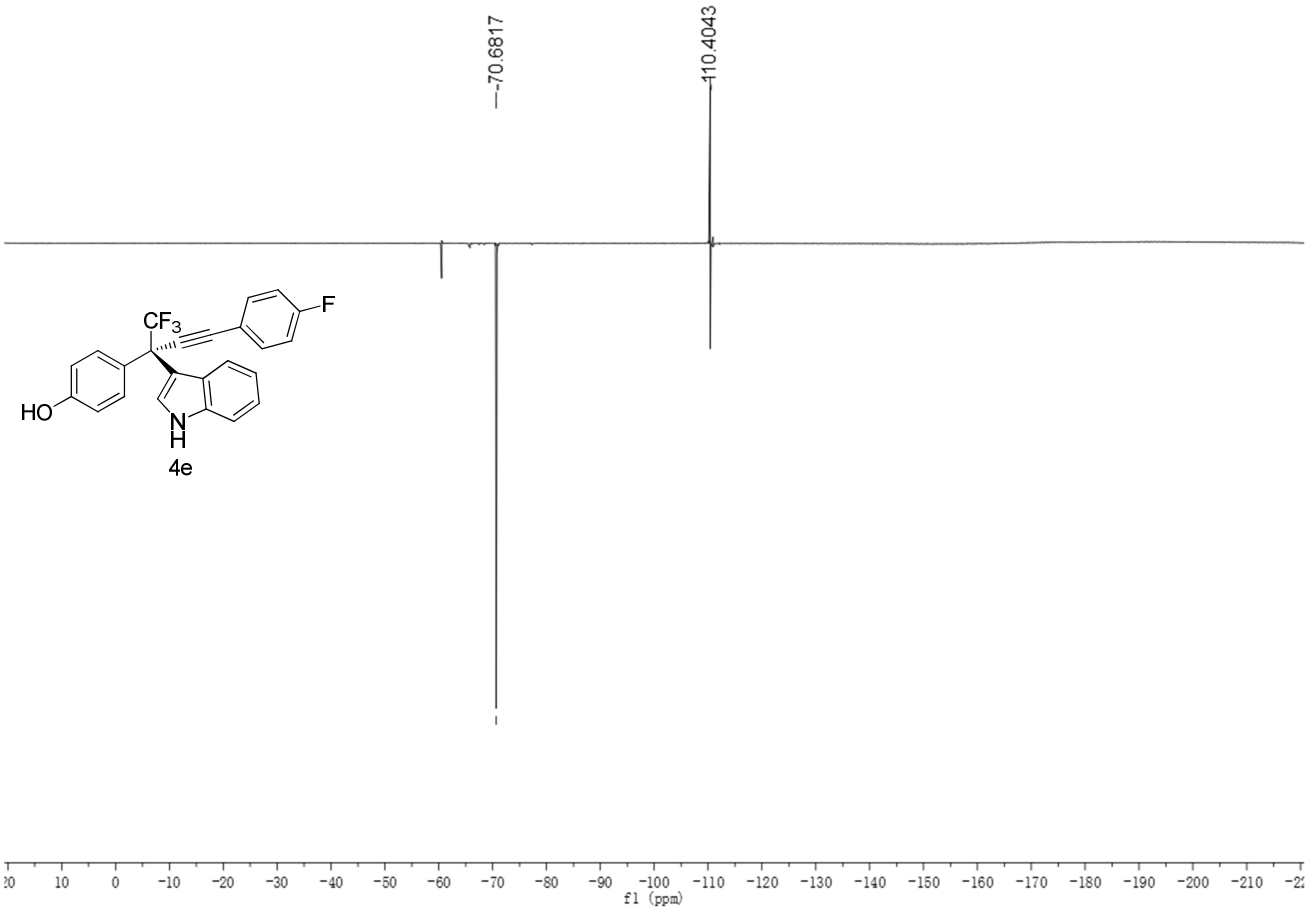
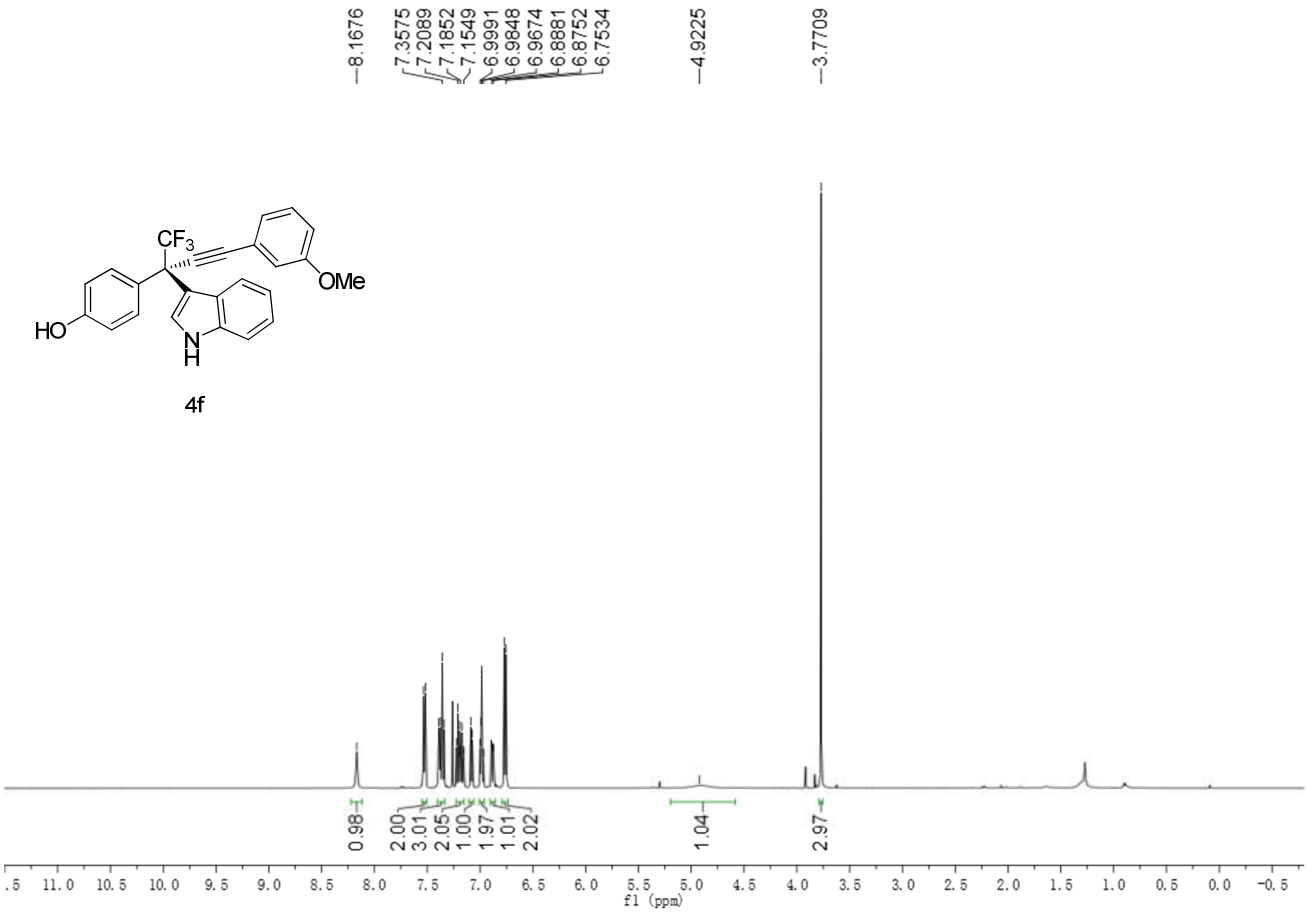
122.6974
122.3730
121.2100
120.1052
118.7292
118.7016
115.8492
115.6732
115.2058
112.5445
111.4144
86.0032
85.9902
85.4518
51.5728
51.3441
51.1122
50.8788
CF3
F
HO
N
H
4e
f1 (ppm)


-70.6817
110.4043
CF3
F
HO
N
H
4e
f1 (ppm)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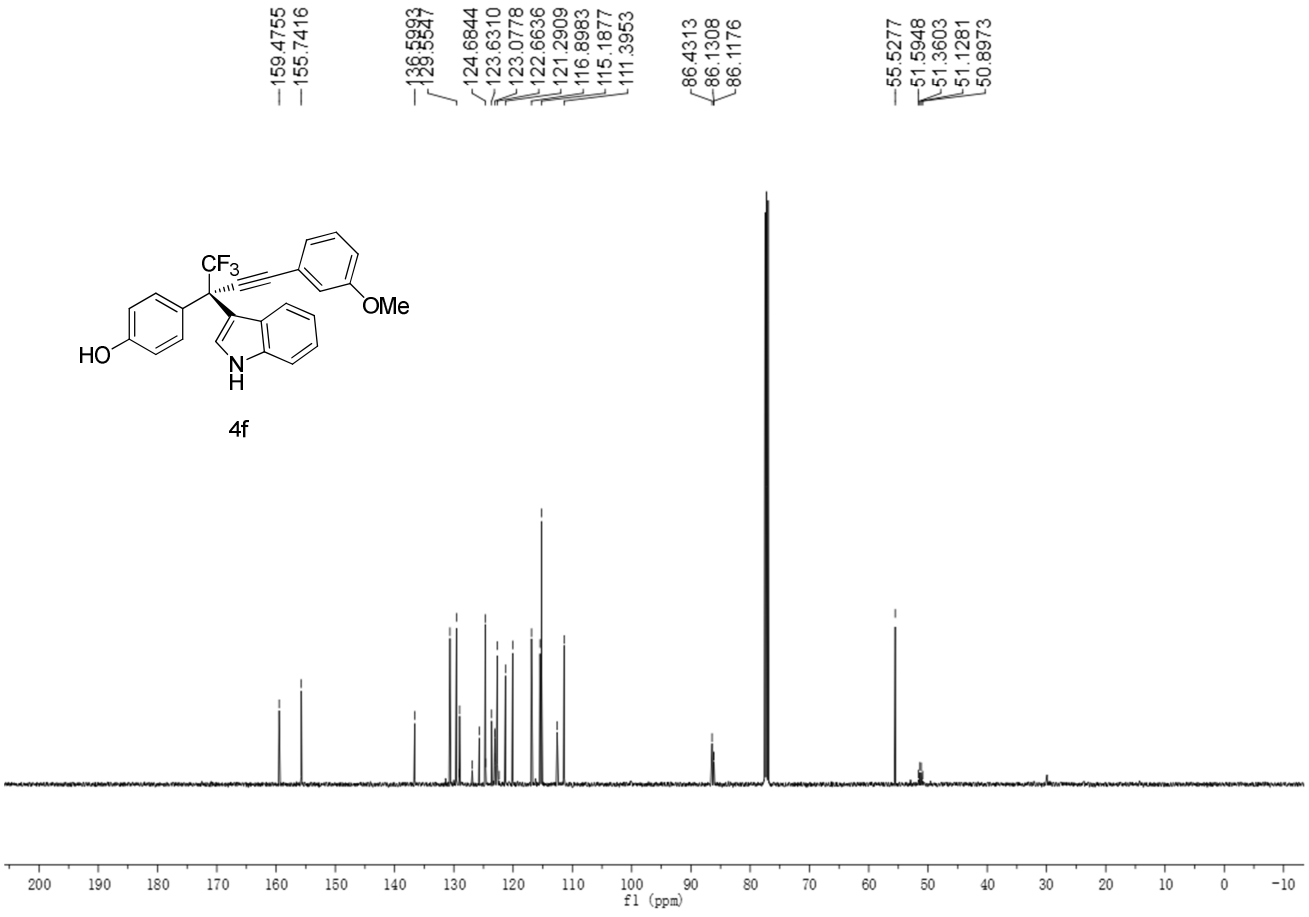
7.3575
7.2089
7.1852
7.1549
6.9991
6.9848
6.9674
6.8881
6.8752
6.7534
4.9225
3.7709
CF3
OMe
HO
N
H
0.98
2.00
3.01
2.05
1.00
1.97
1.01
2.02
1.04
2.97
f1 (ppm)

4f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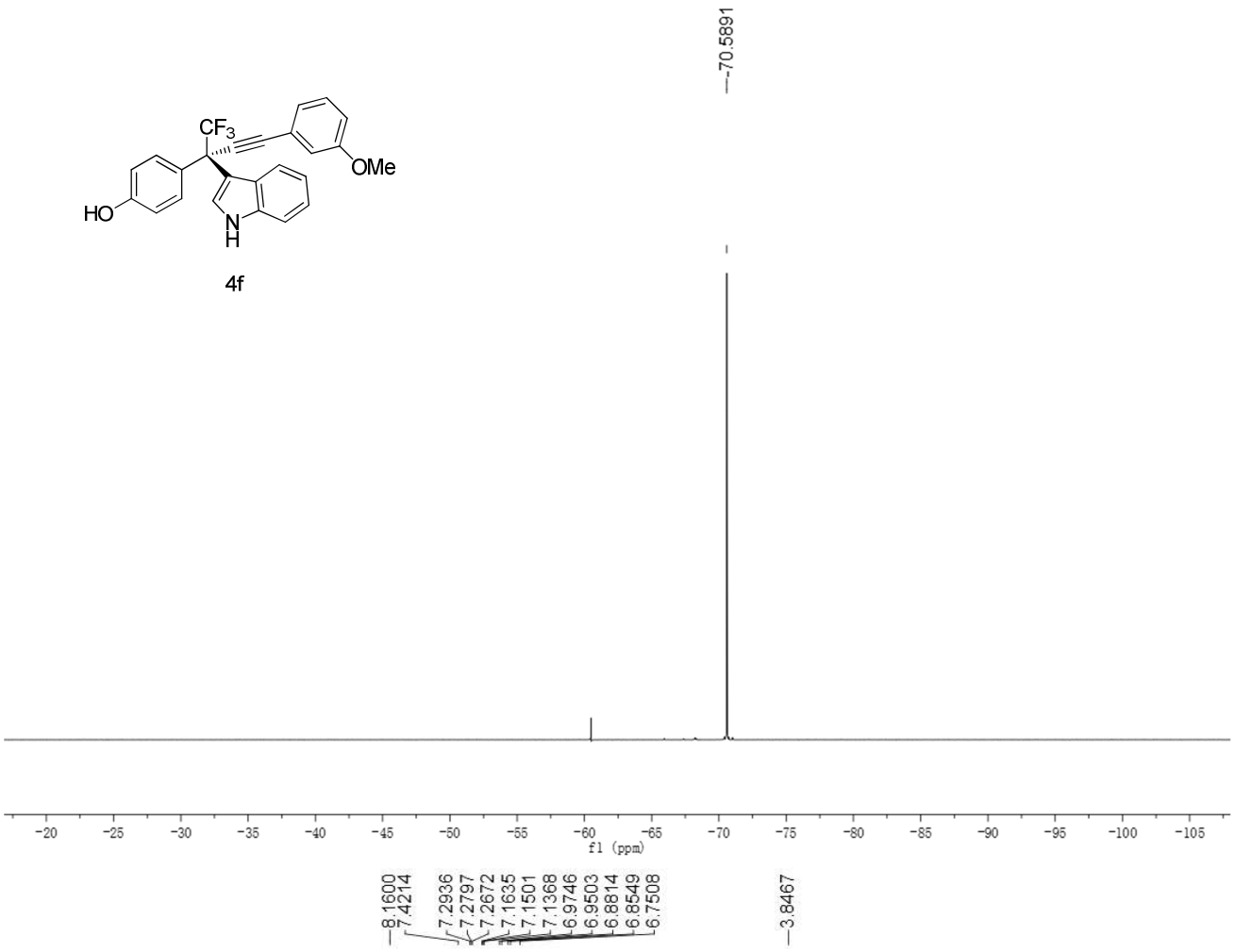
121.2909
116.8983
115.1877
111.3953
86.4313
86.1308
86.1176
55.5277
51.5948
51.3603
51.1281
50.8973
CF3
OMe
HO
N
H
f1 (ppm)

4f

CF3
OMe
HO
N
H

4f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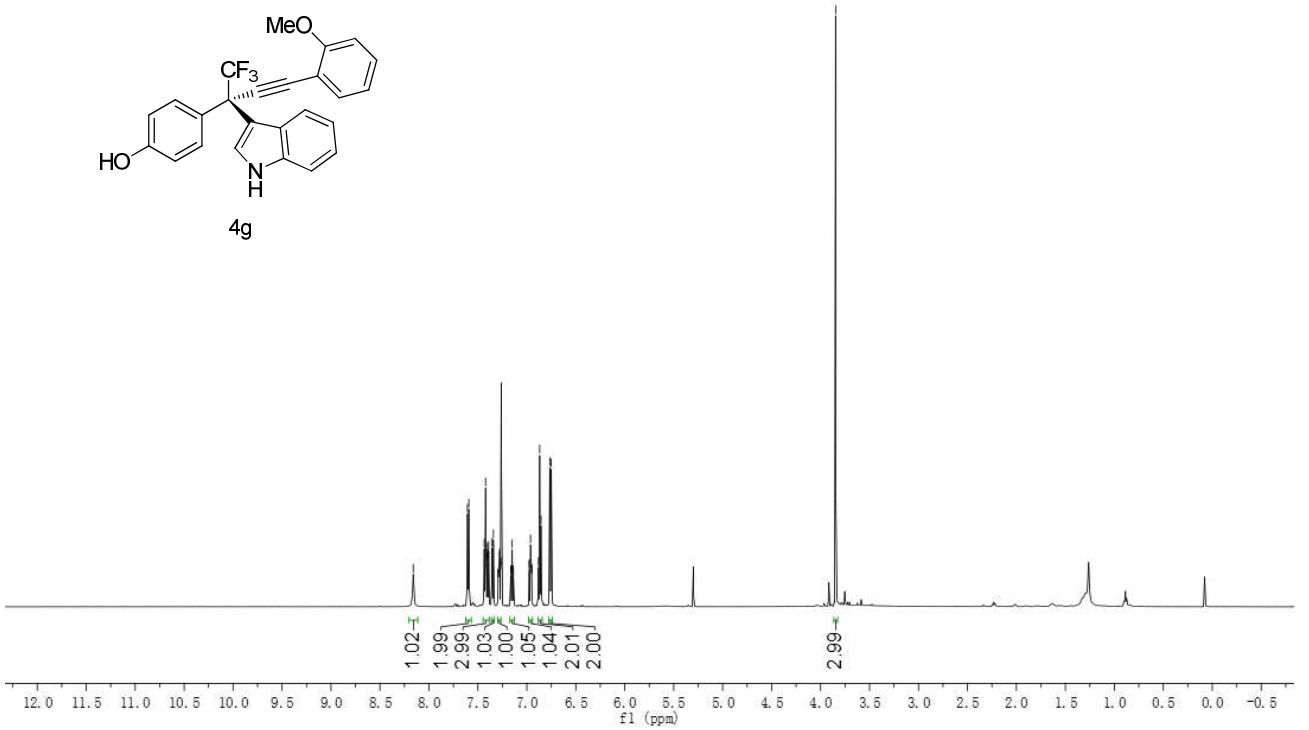
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-100
-105
f1 (ppm)
8.1600
7.4214
7.2936
7.2797
7.2672
7.1635
7.1501
7.1368
6.9746
6.9503
6.8814
6.8549
6.7508
3.8467

MeO
CF3
HO
N
H

4g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1.99
2.99
1.03
1.00
1.05
1.04
2.01
2.00
2.99
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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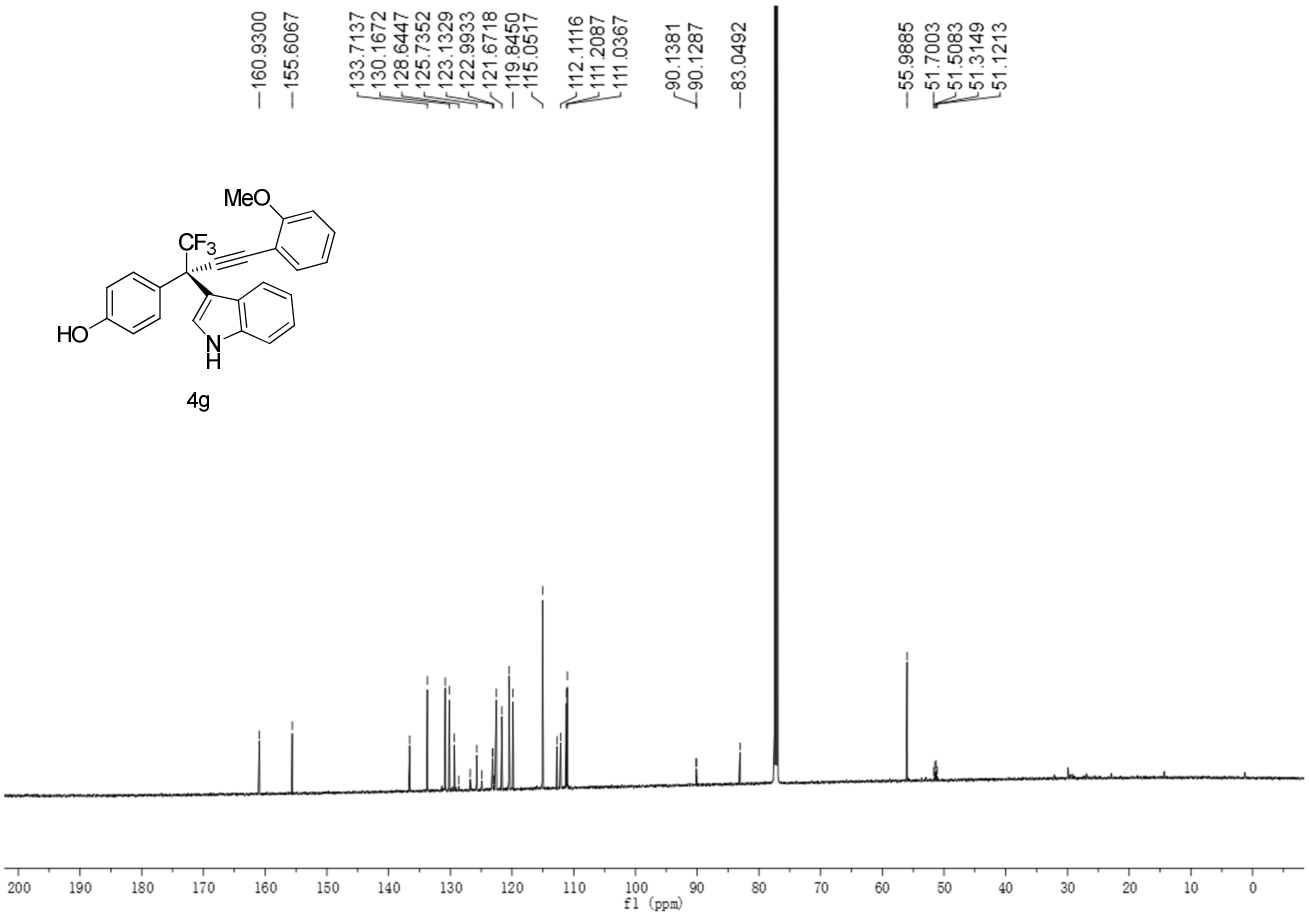
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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133.7137
130.1672
128.6447
125.7352
123.1329
122.9933
121.6718
119.8450
115.0517
112.1116
111.2087
111.0367
90.1381
90.1287
83.0492
55.9885
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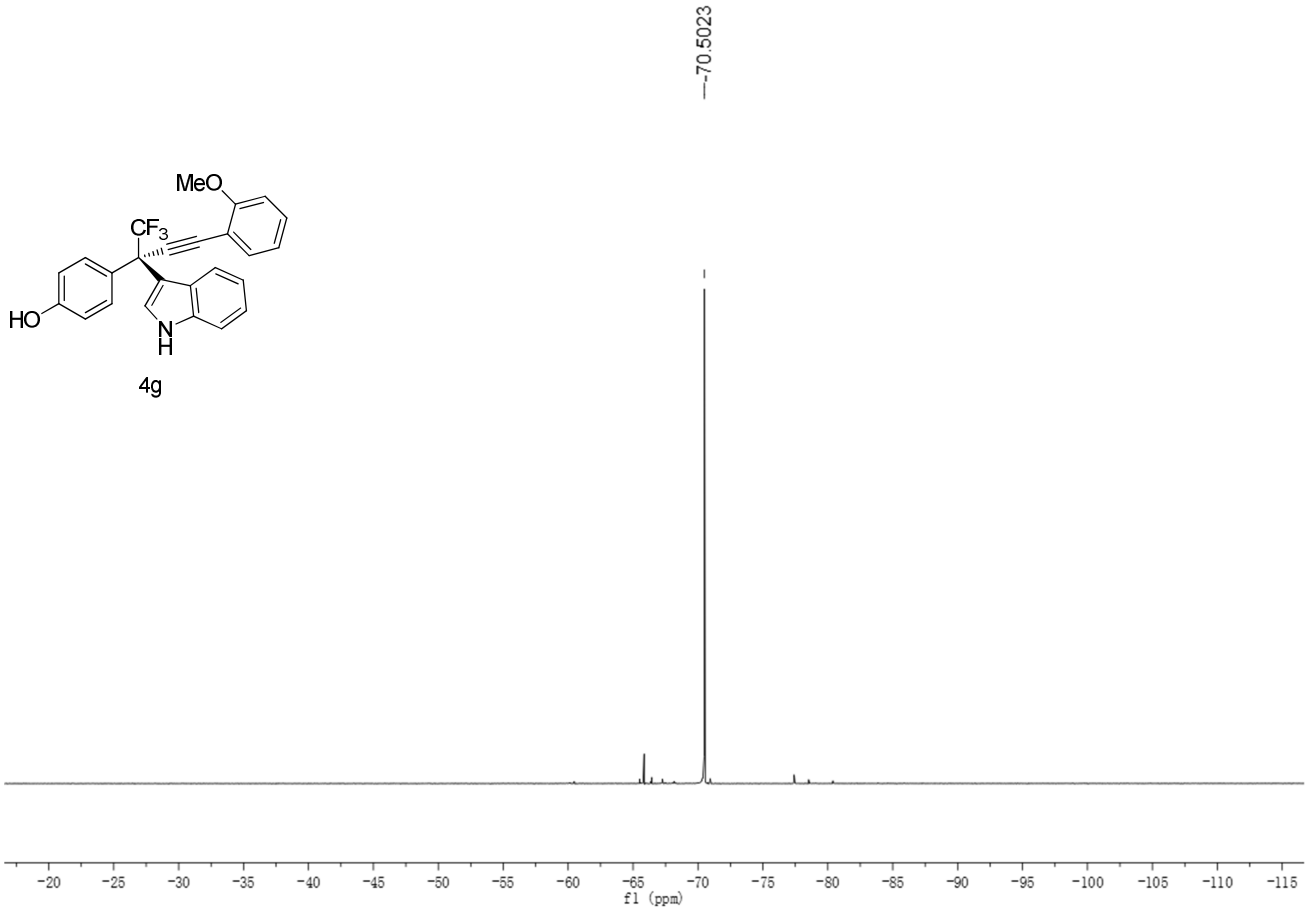
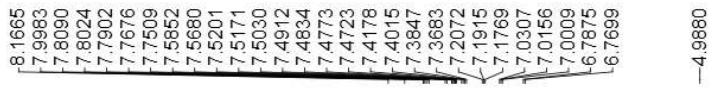
51.5083
51.3149
51.1213
MeO
CF3
HO
N
H
4g
f1 (ppm)


70.5023
MeO
CF3
HO
N
H
4g
f1 (ppm)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7.5680
7.5201
7.5171
7.5030
7.4912
7.4834
7.4773
7.4723
7.4178
7.4015
7.3847
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7.1915
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7.0307
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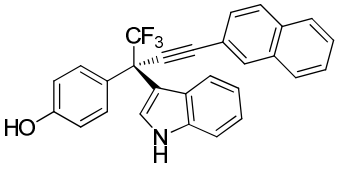
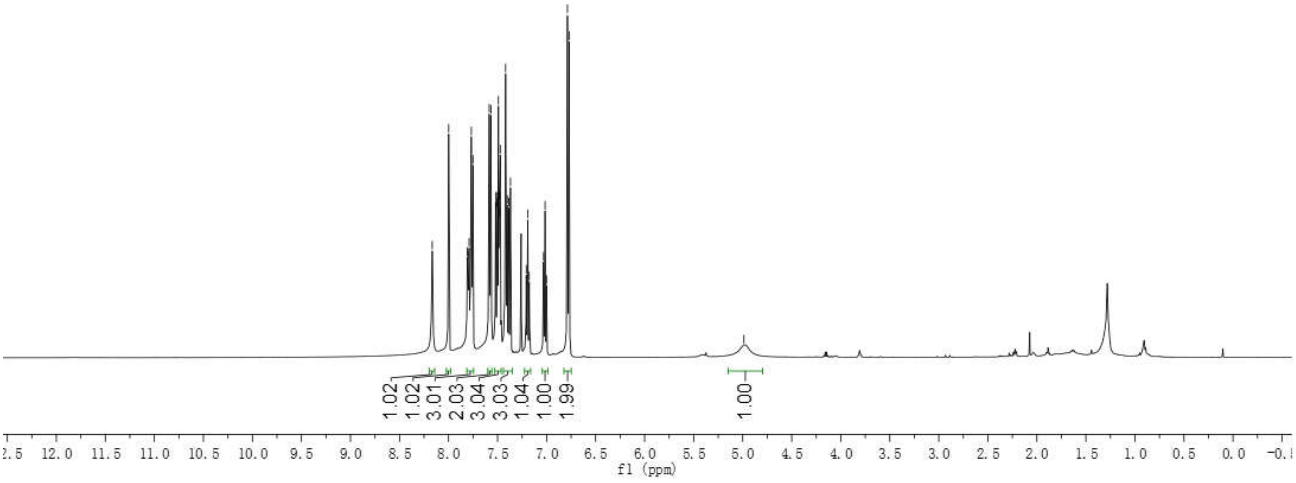
7.0009
6.7875
6.7699
4.9880


CF3
HO
N
H

4h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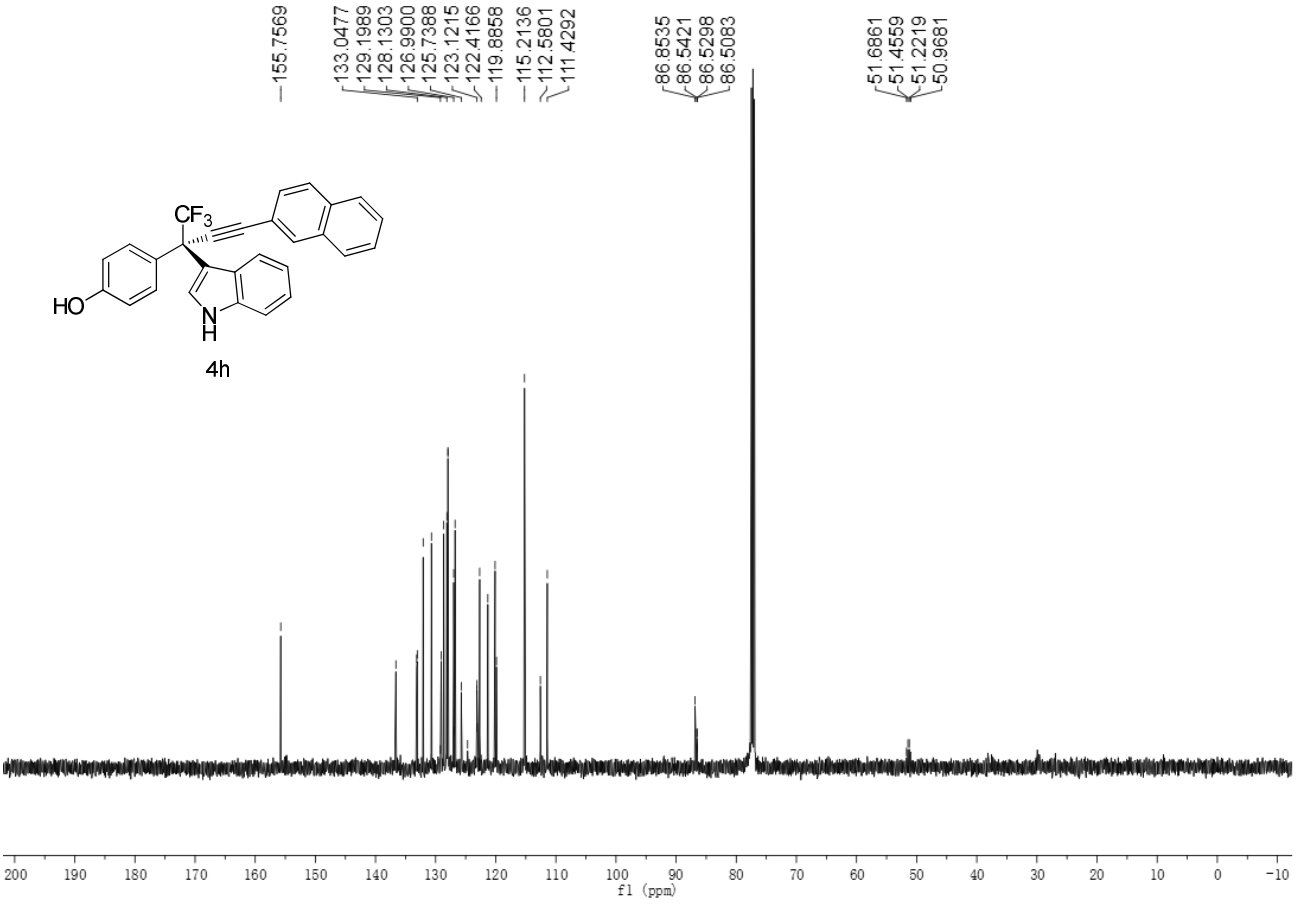
1.02
3.01
2.03
3.04
3.03
1.04
1.00
1.99
1.00
f1 (ppm)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125.7388
123.1215
122.4166
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115.2136
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111.4292
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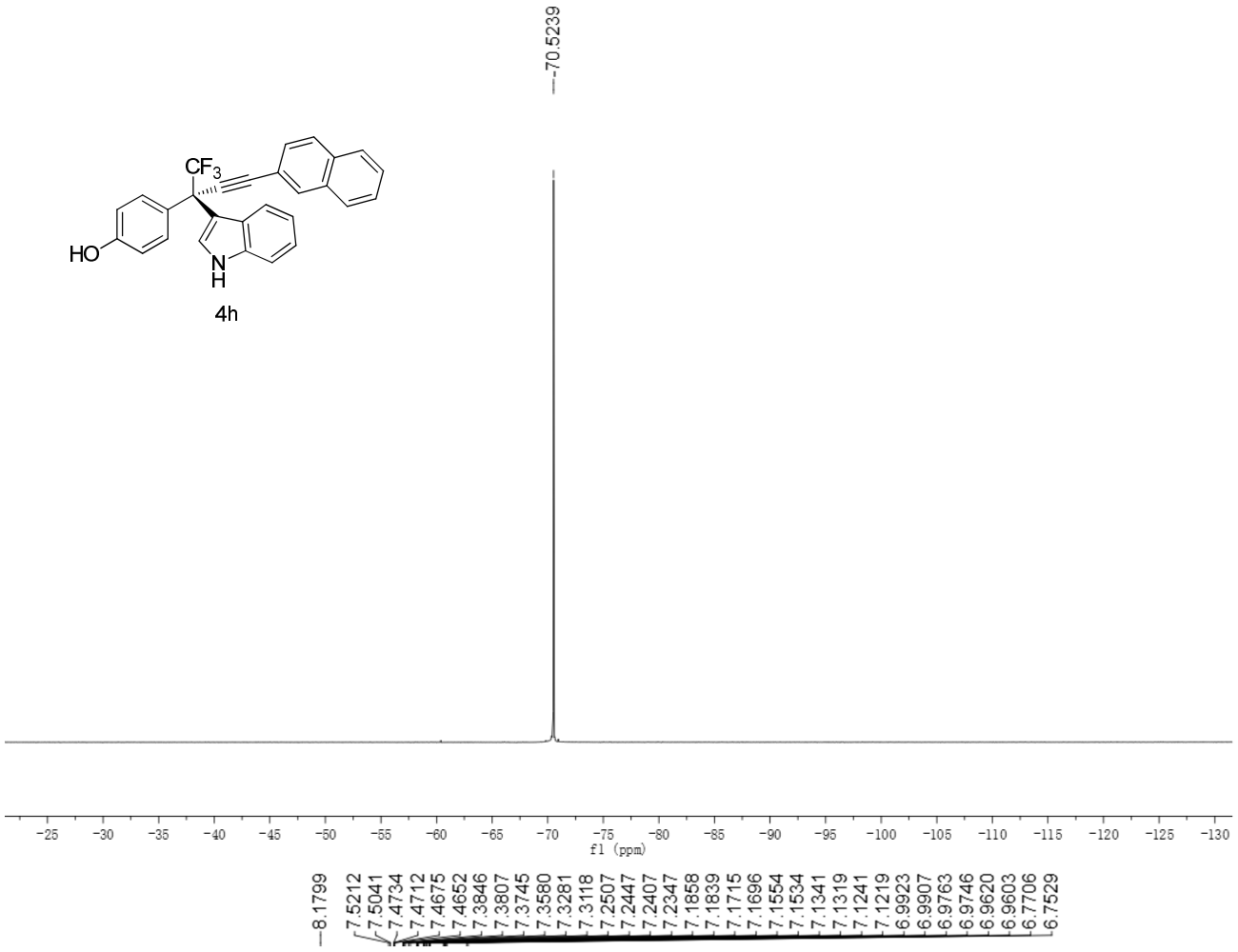
86.5421
86.5298
86.5083
51.6861
51.4559
51.2219
50.9681
f1 (ppm)

CF3
HO
N
H

4h

CF3
HO
N
H

4h


-70.5239
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125 -130
f1 (ppm)
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7.5212
7.5041
7.4734
7.4712
7.4675
7.4652
7.3846
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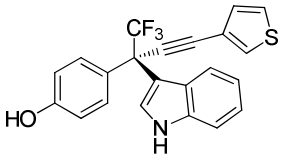
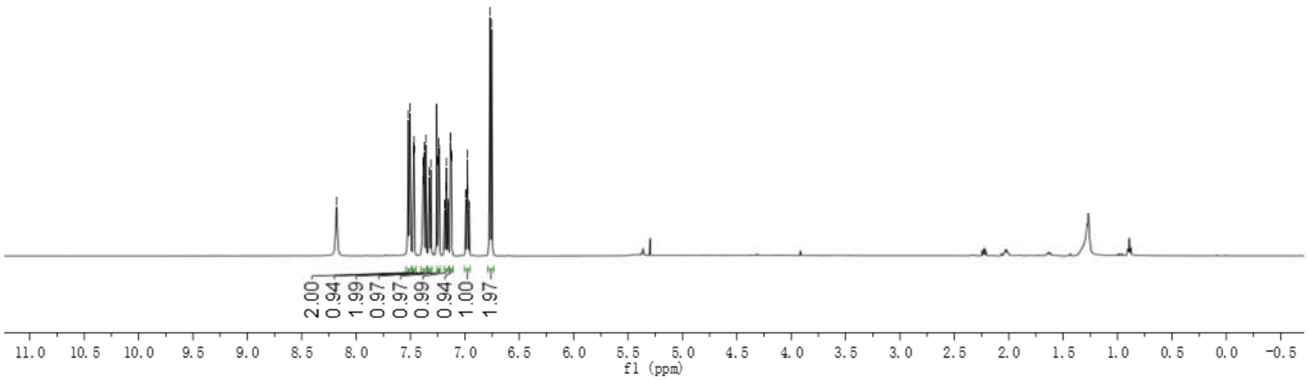
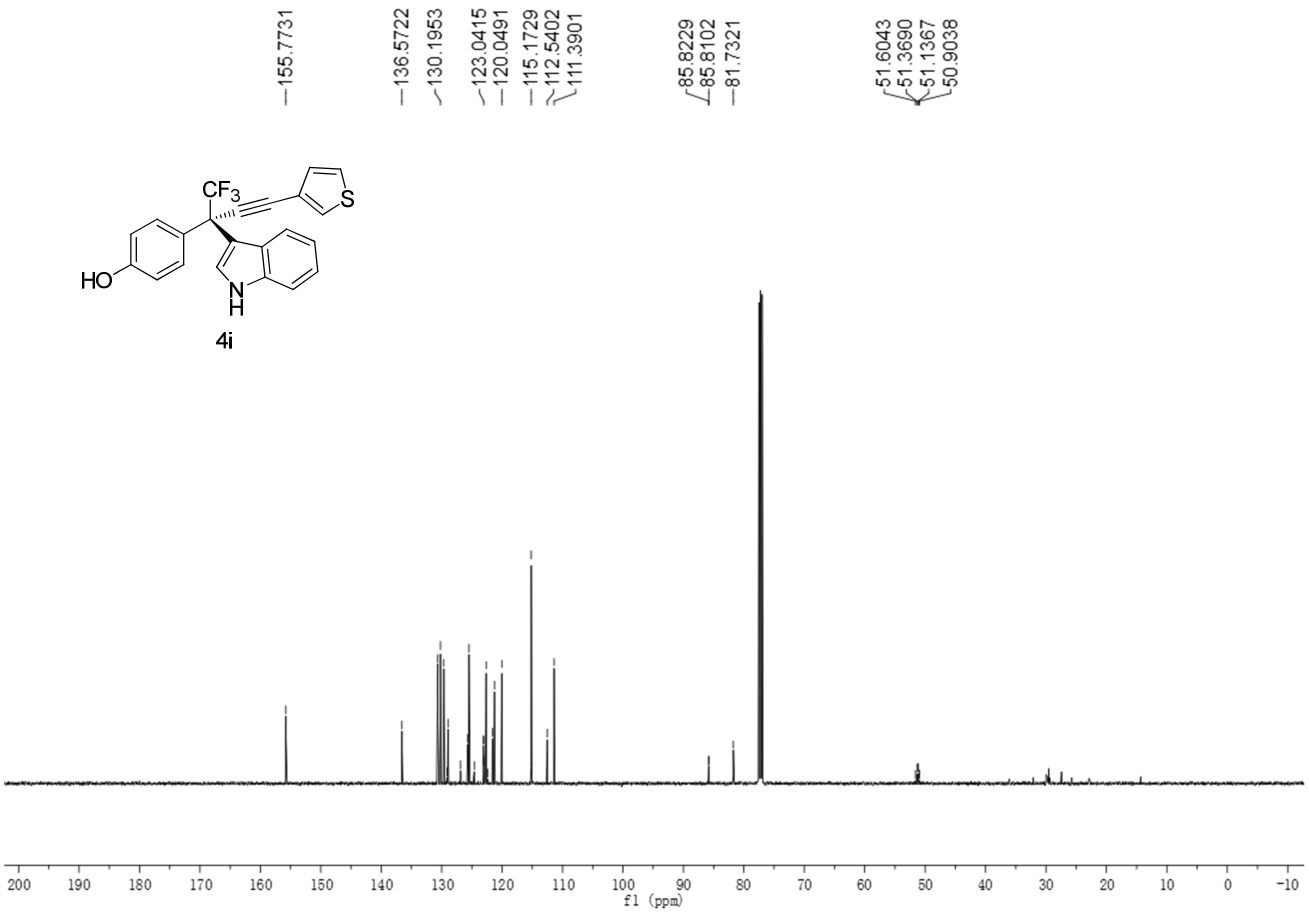
6.7706
6.7529

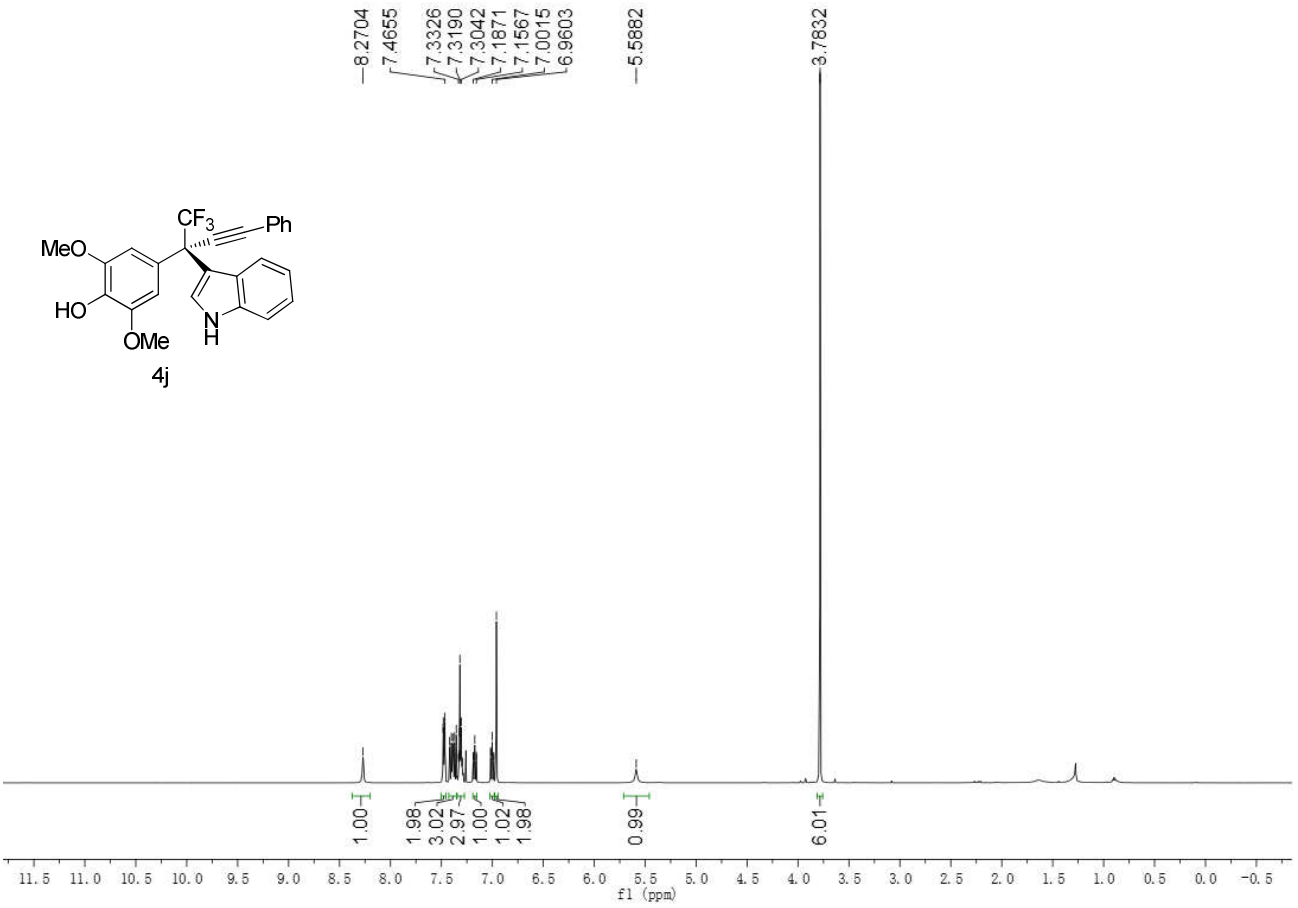

CF3
S
HO
N
H

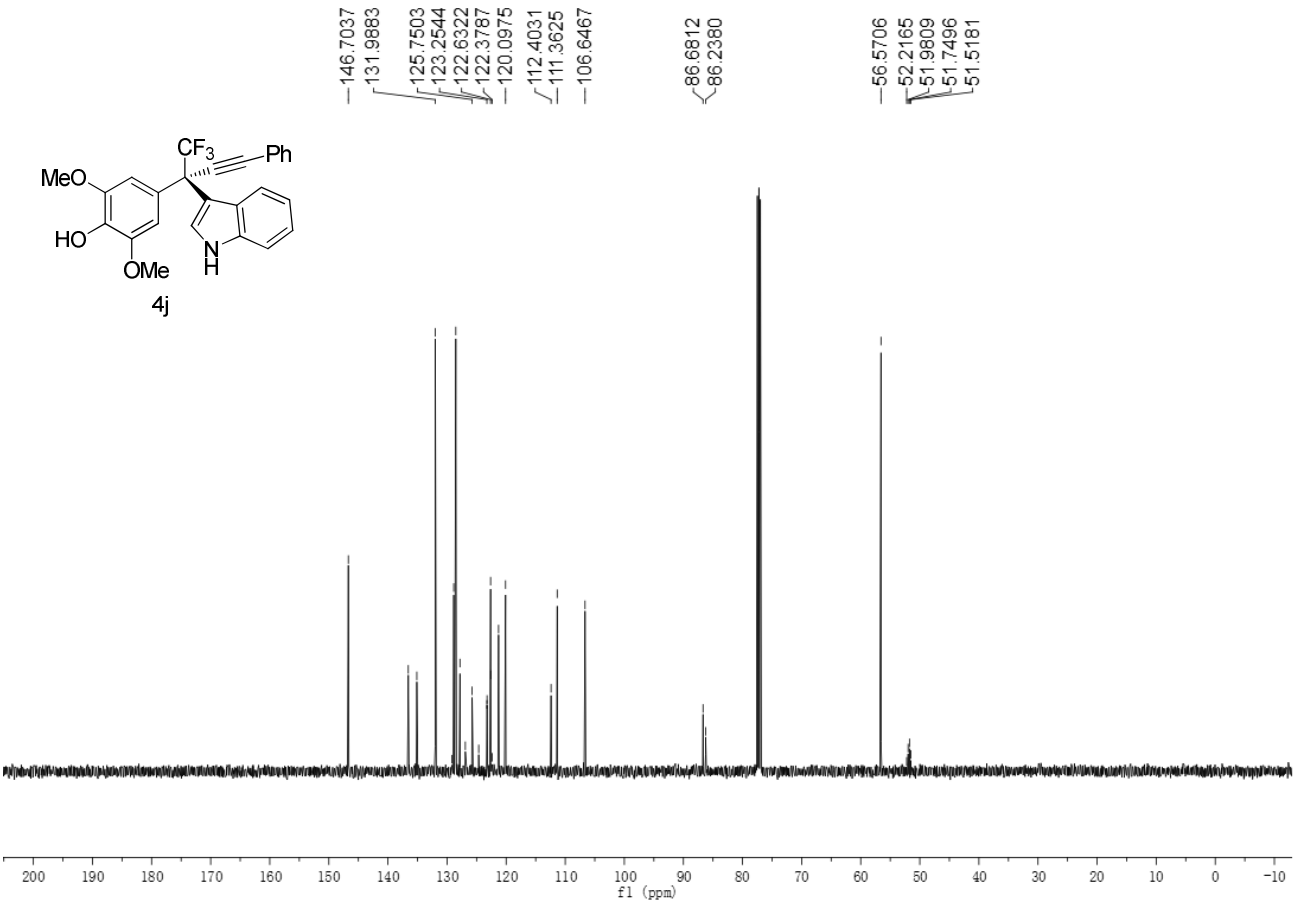
4i


2.00
0.94
1.99
0.97
0.97
0.99
0.94
1.00
1.97
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


155.7731
136.5722
130.1953
123.0415
120.0491
115.1729
112.5402
111.3901
85.8229
85.8102
81.7321
51.6043
51.3690
51.1367
50.9038
CF3
S
HO
N
H
4i
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

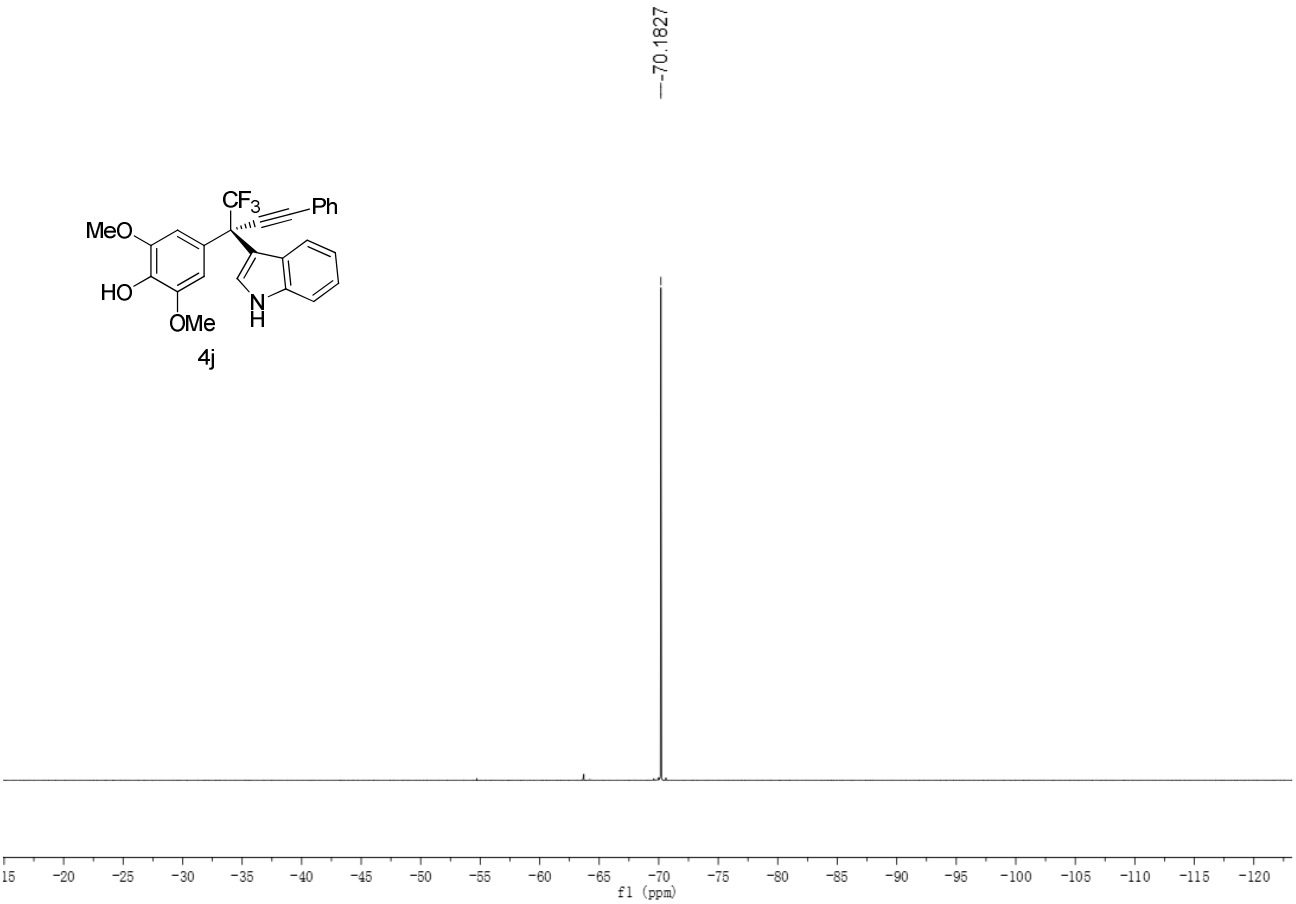

-70.5933
CF3
S
HO
N
H
4i
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105
f1 (ppm)


8.2704
7.4655
7.3326
7.3190
7.3042
7.1871
7.1567
7.0015
6.9603
5.5882
3.7832
CF3
Ph
MeO
HO
OMe
N
H
4j
1.00
1.98
3.02
2.97
1.00
1.02
1.98
0.99
6.01
f1 (ppm)


146.7037
131.9883
125.7503
123.2544
122.6322
122.3787
120.0975
112.4031
111.3625
106.6467
86.6812
86.2380
56.5706
52.2165
51.9809
51.7496
51.5181
CF3
Ph
MeO
HO
OMe
N
H
4j
f1 (ppm)

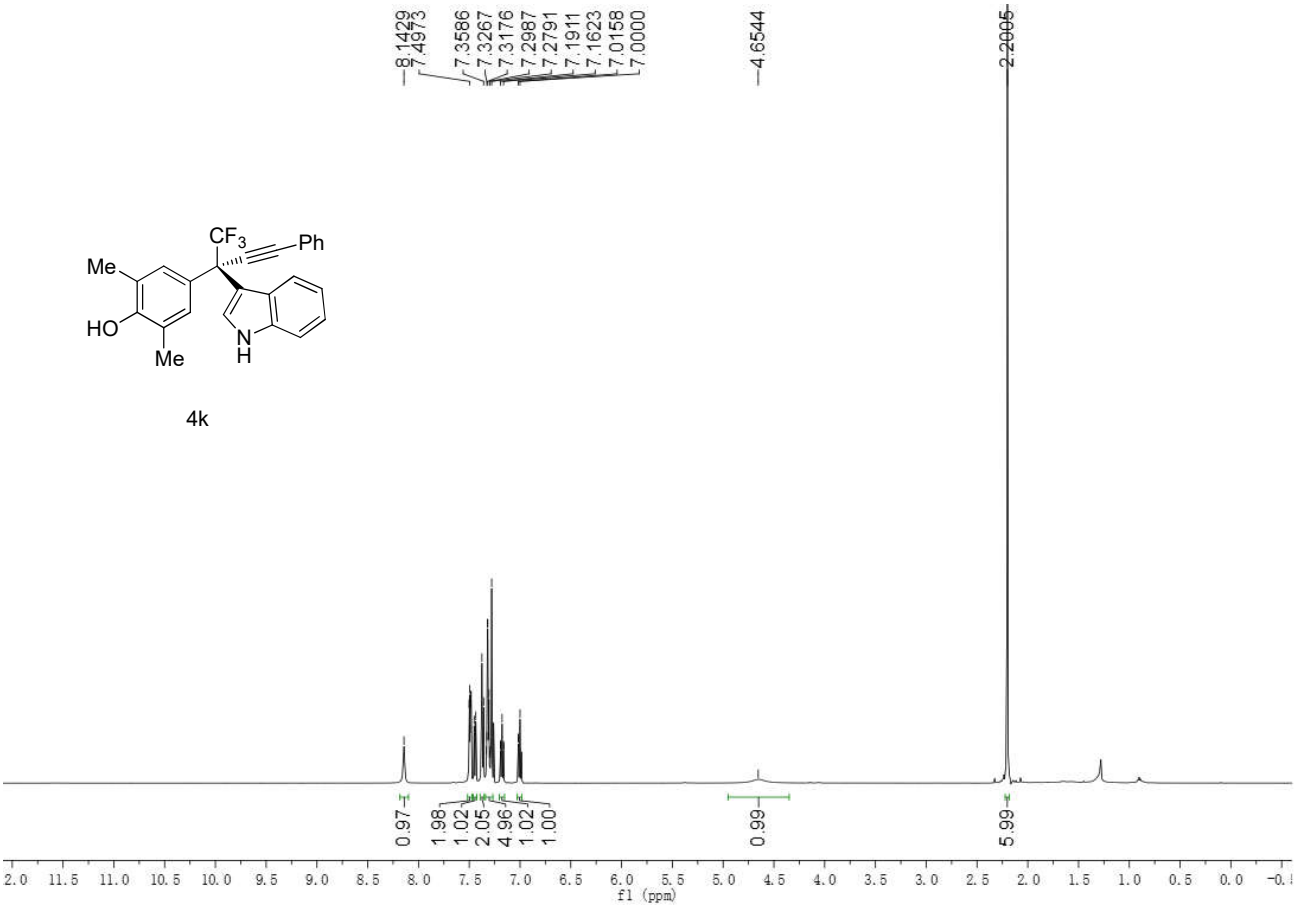
MeO
HO
OMe
CF3
Ph
N
H

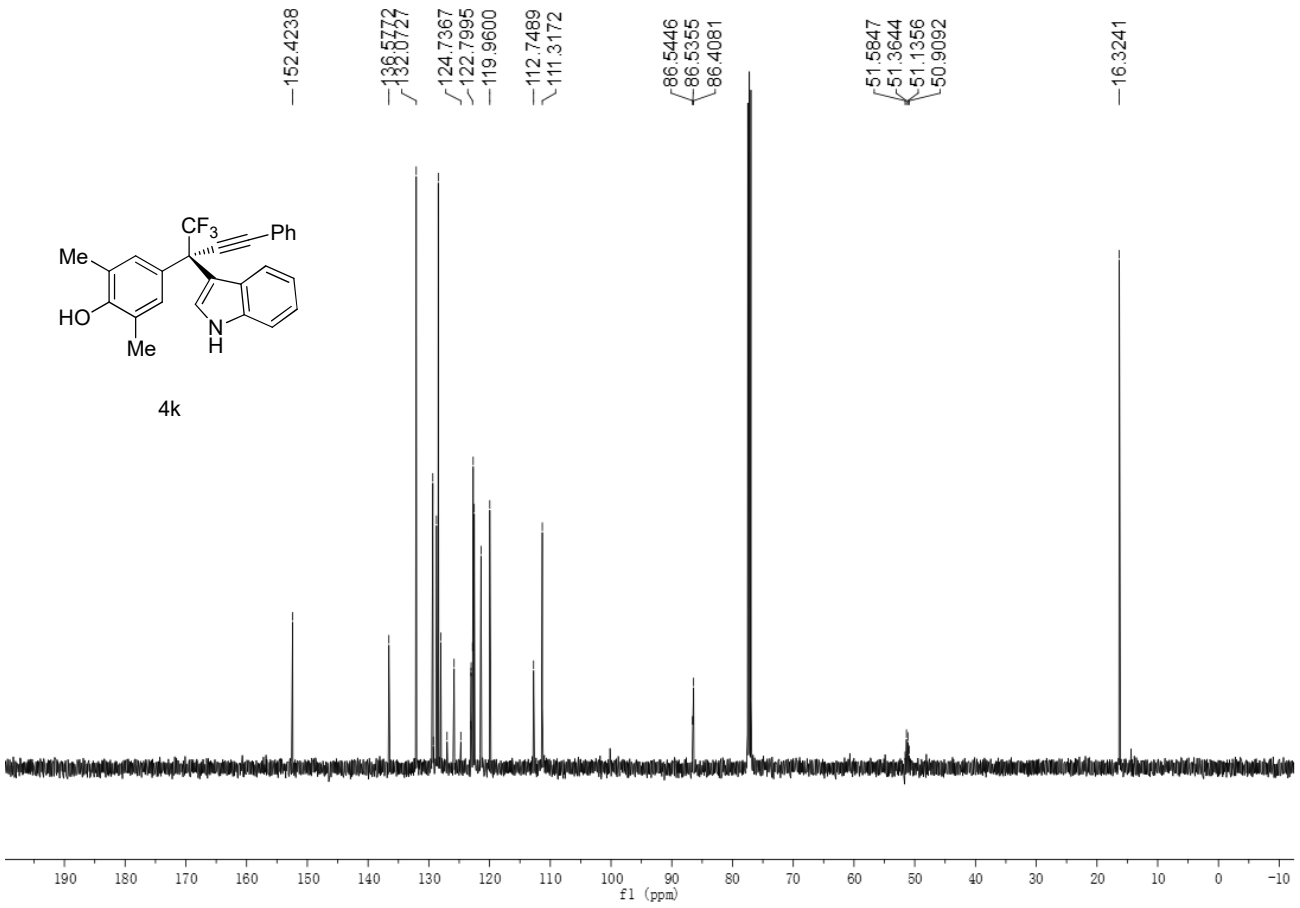
4j

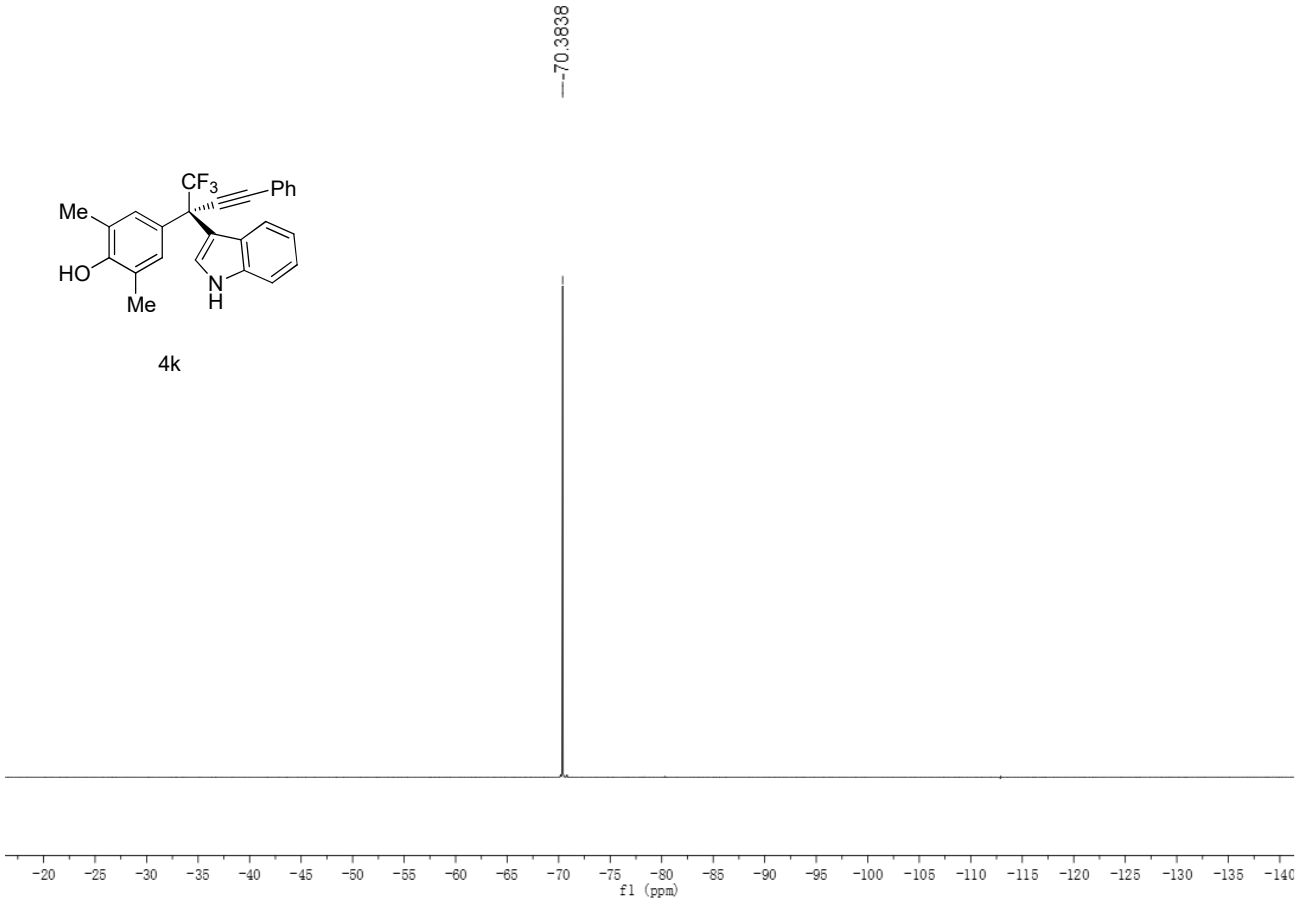

-70.1827
f1 (ppm)

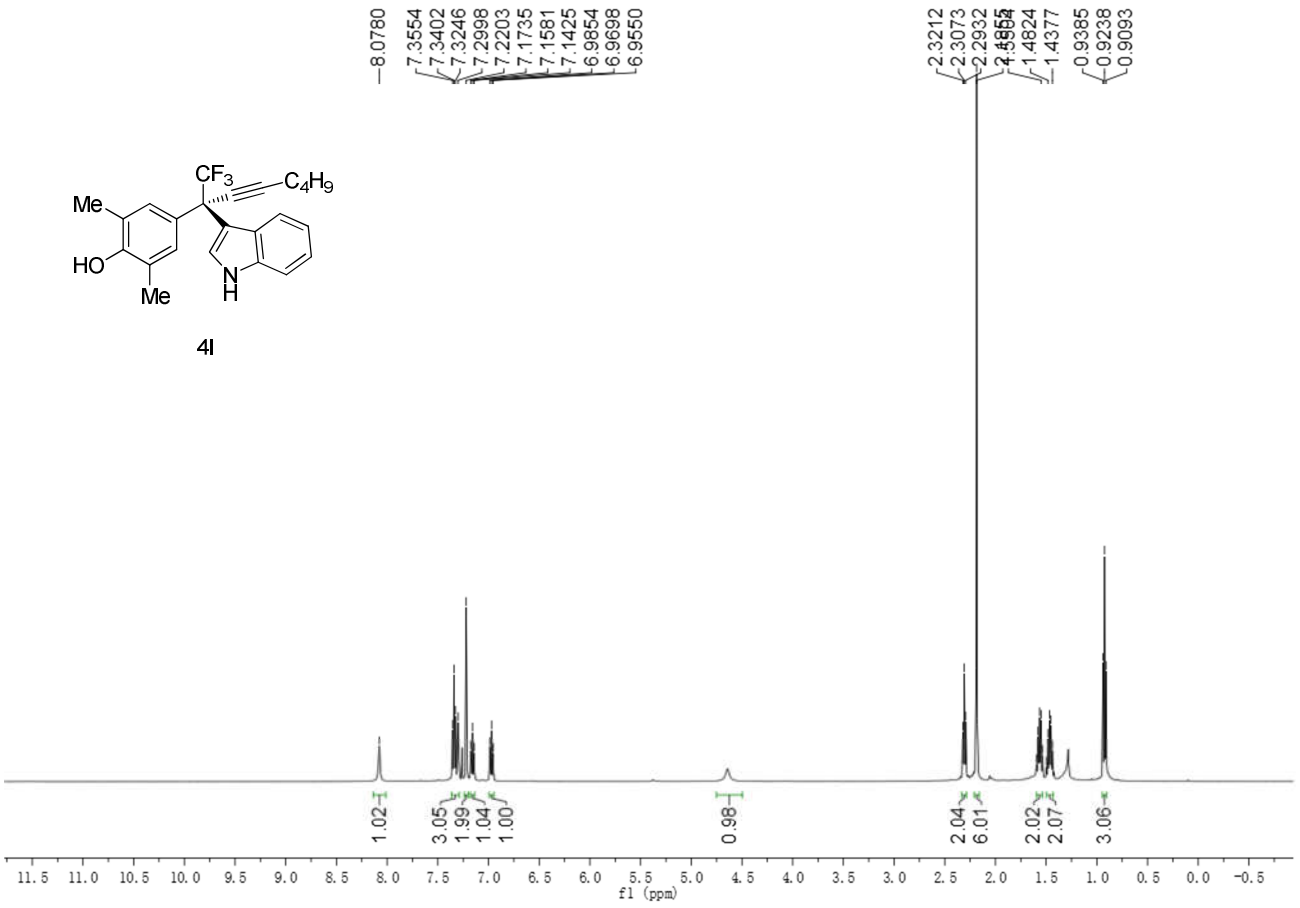
Me
HO
Me
CF3
Ph
N
H

4k


8.1429
7.4973
7.3586
7.3267
7.3176
7.2987
7.2791
7.1911
7.1623
7.0158
7.0000
4.6544
2.2005
0.97
1.98
1.02
2.05
4.96
1.02
1.00
0.99
5.99
f1 (ppm)

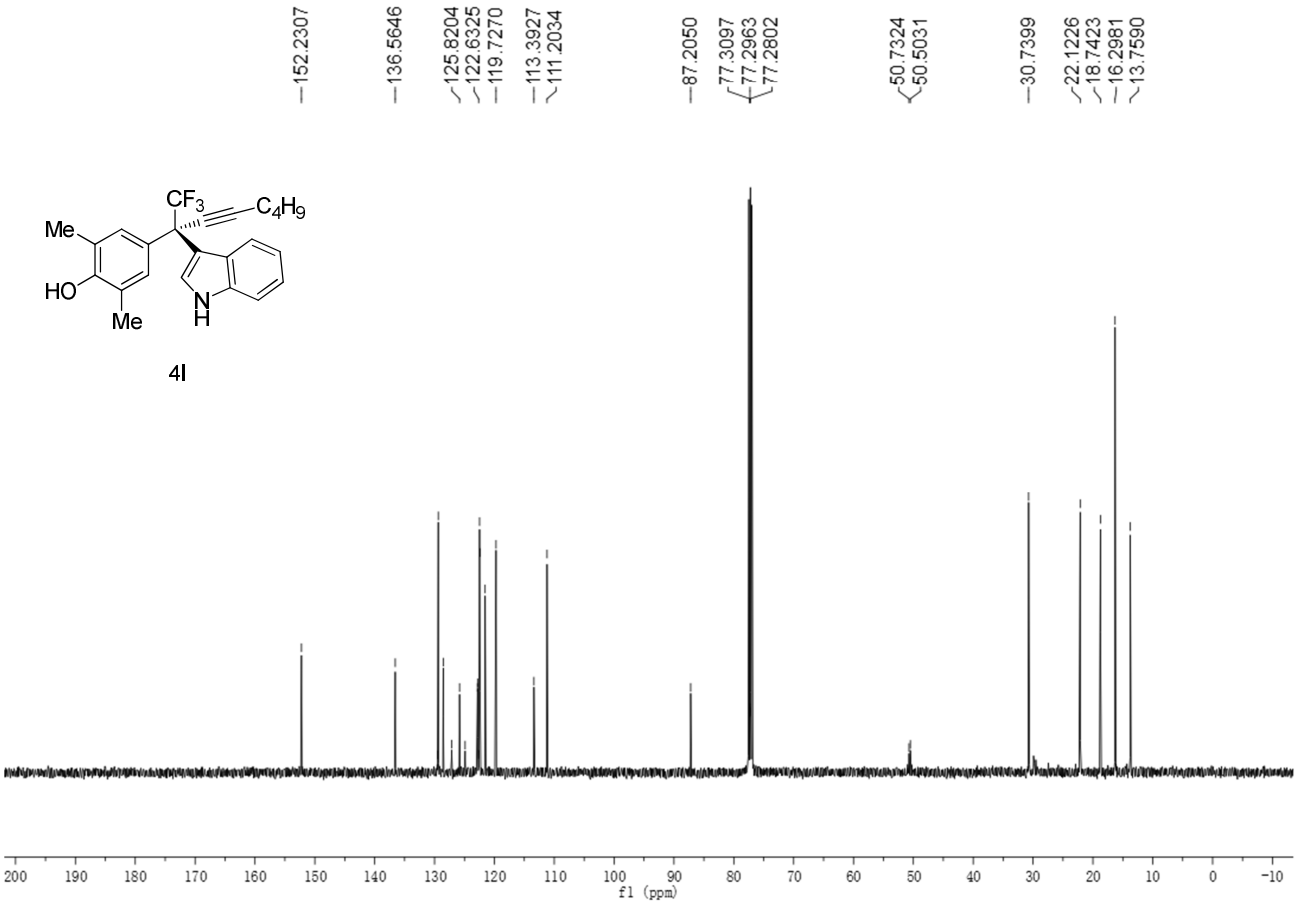

152.4238
136.5772
132.0727
124.7367
122.7995
119.9600
112.7489
111.3172
86.5446
86.5355
86.4081
51.5847
51.3644
51.1356
50.9092
16.3241
CF3
Ph
Me
HO
Me
N
H
4k
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


-70.3838
CF3
Ph
Me
HO
Me
N
H
4k
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-100
-105
-110
-115
-120
-125
-130
-135
-140
f1 (ppm)


8.0780
7.3554
7.3402
7.3246
7.2998
7.2203
7.1735
7.1581
7.1425
6.9854
6.9698
6.9550
2.3212
2.3073
2.2932
1.4824
1.4377
0.9385
0.9238
0.9093
1.02
3.05
1.99
1.04
1.00
0.98
2.04
6.01
2.02
2.07
3.06
f1 (ppm)

CF3
C4H9
Me
HO
Me
N
H

4l

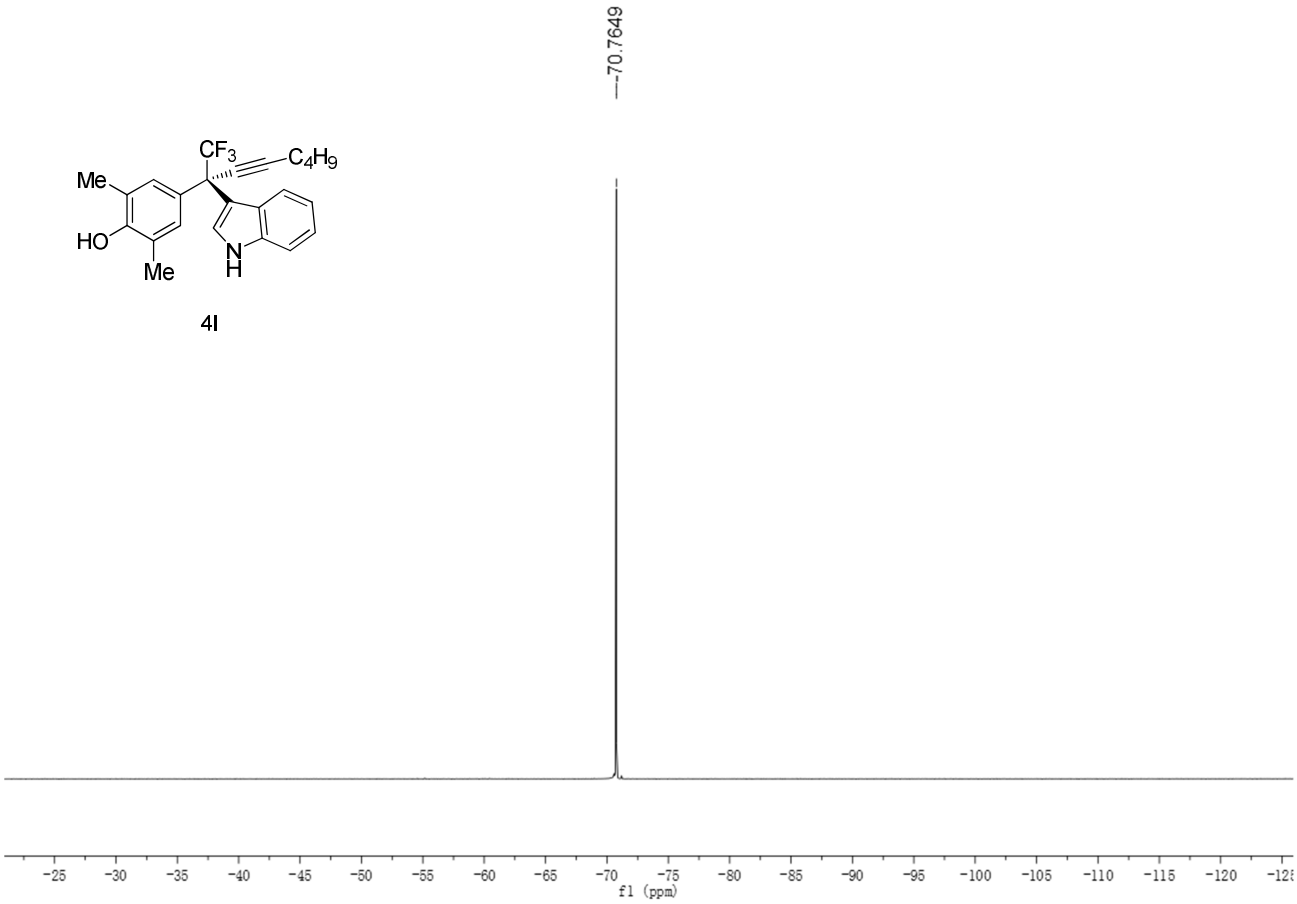

152.2307
136.5646
125.8204
122.6325
119.7270
113.3927
111.2034
87.2050
77.3097
77.2963
77.2802
50.7324
50.5031
30.7399
22.1226
18.7423
16.2981
13.7590
f1 (ppm)

CF3
C4H9
Me
HO
Me
N
H

4l

CF3
C4H9
Me
HO
Me
N
H

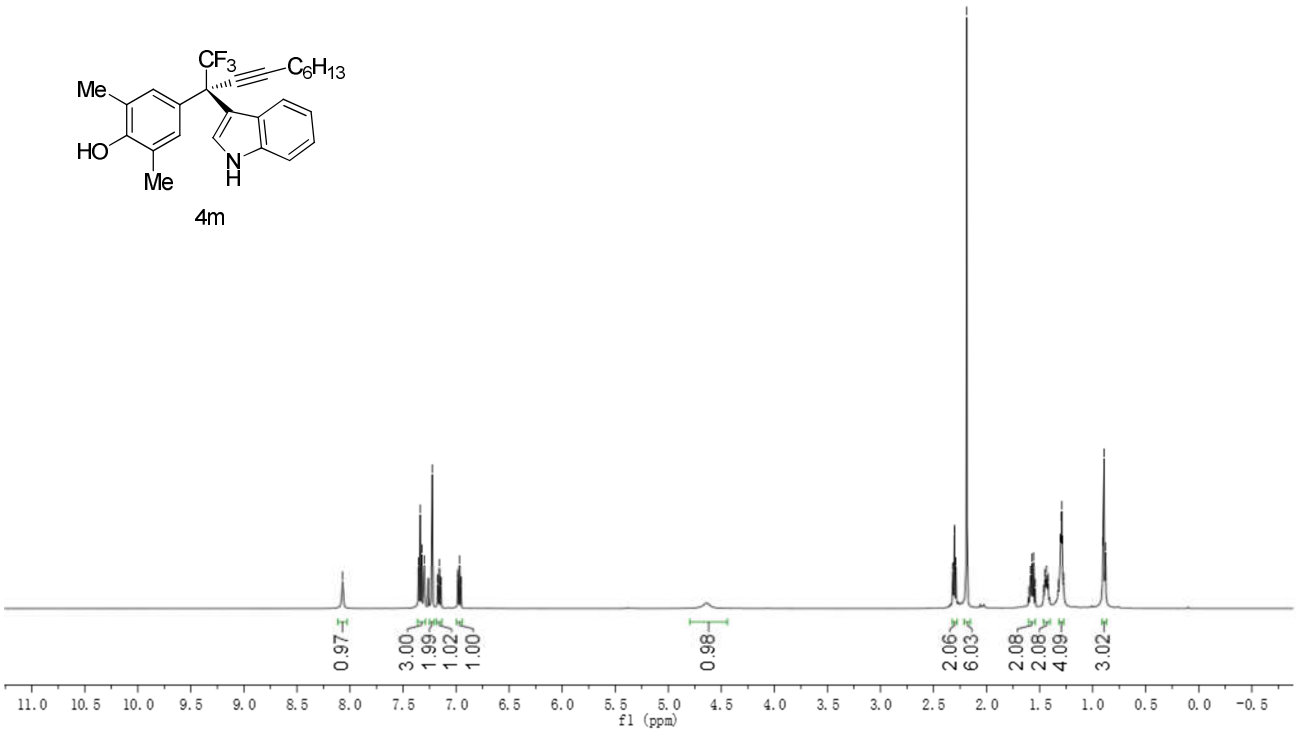
4l

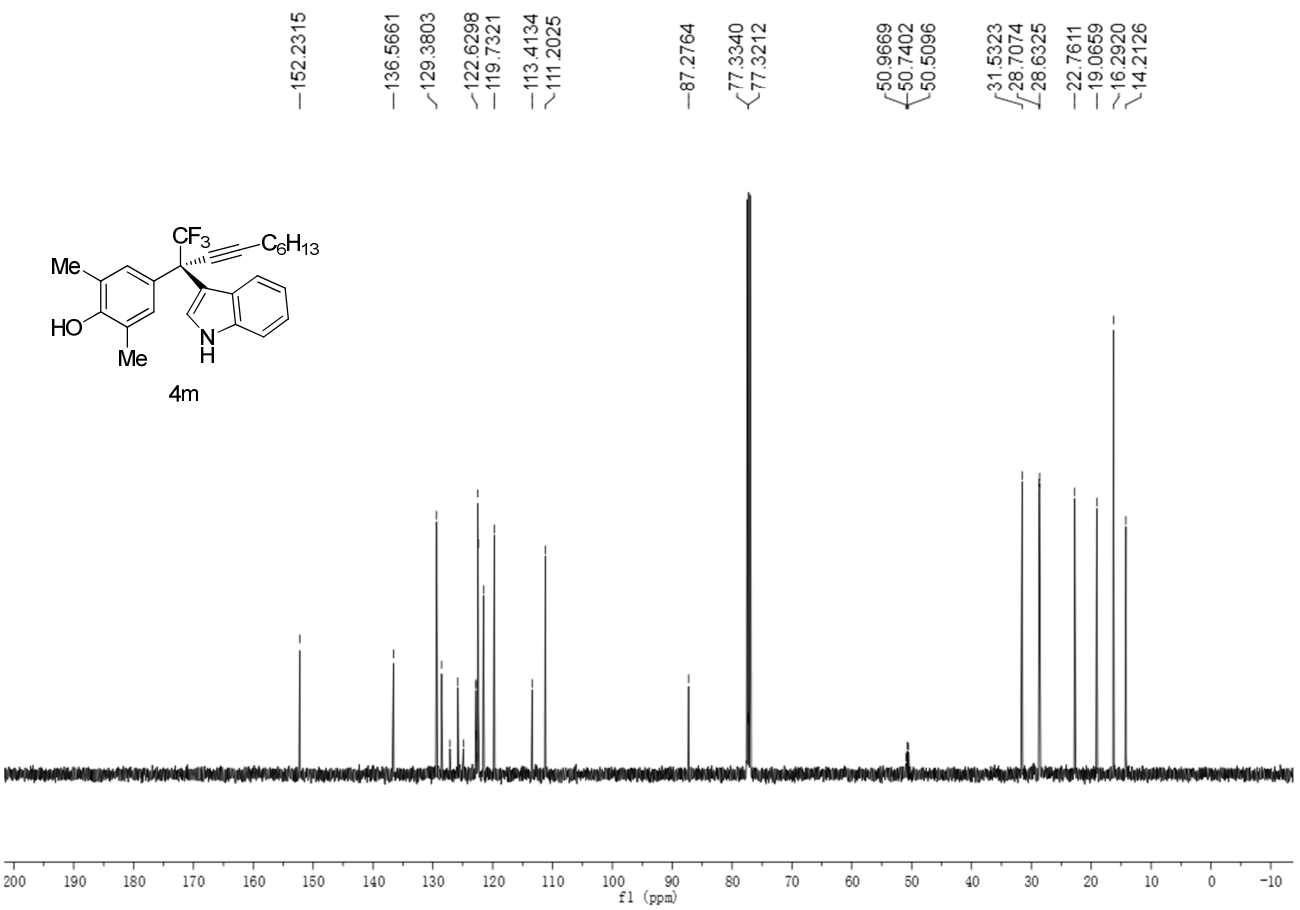

-70.7649
f1 (ppm)


8.0697
7.3380
7.3220
7.2997
7.2246
7.1741
7.1724
7.1579
7.1439
7.1419
6.9838
6.9821
6.9680
6.9534
6.9520
2.3176
2.3150
2.3034
2.3014
2.2891
2.1866
1.4648
1.3228
1.2758
0.9055
0.8916
0.8839
0.8776

CF3
C6H13
Me
HO
Me
N
H

4m


0.97
3.00
1.99
1.02
1.00
0.98
2.06
6.03
2.08
2.08
4.09
3.02
f1 (ppm)


152.2315
136.5661
129.3803
122.6298
119.7321
113.4134
111.2025
87.2764
77.3340
77.3212
50.9669
50.7402
50.5096
31.5323
28.7074
28.6325
22.7611
19.0659
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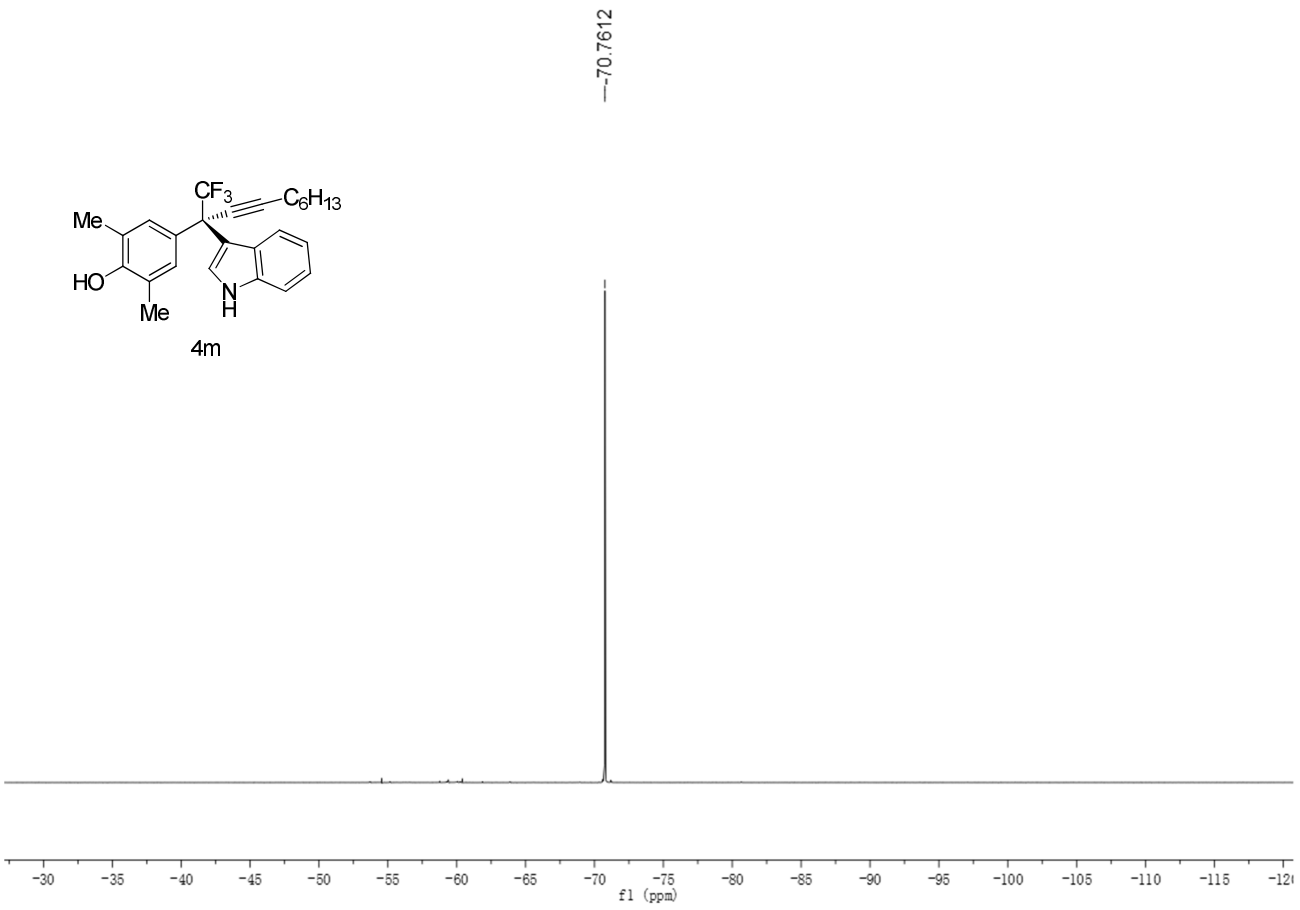
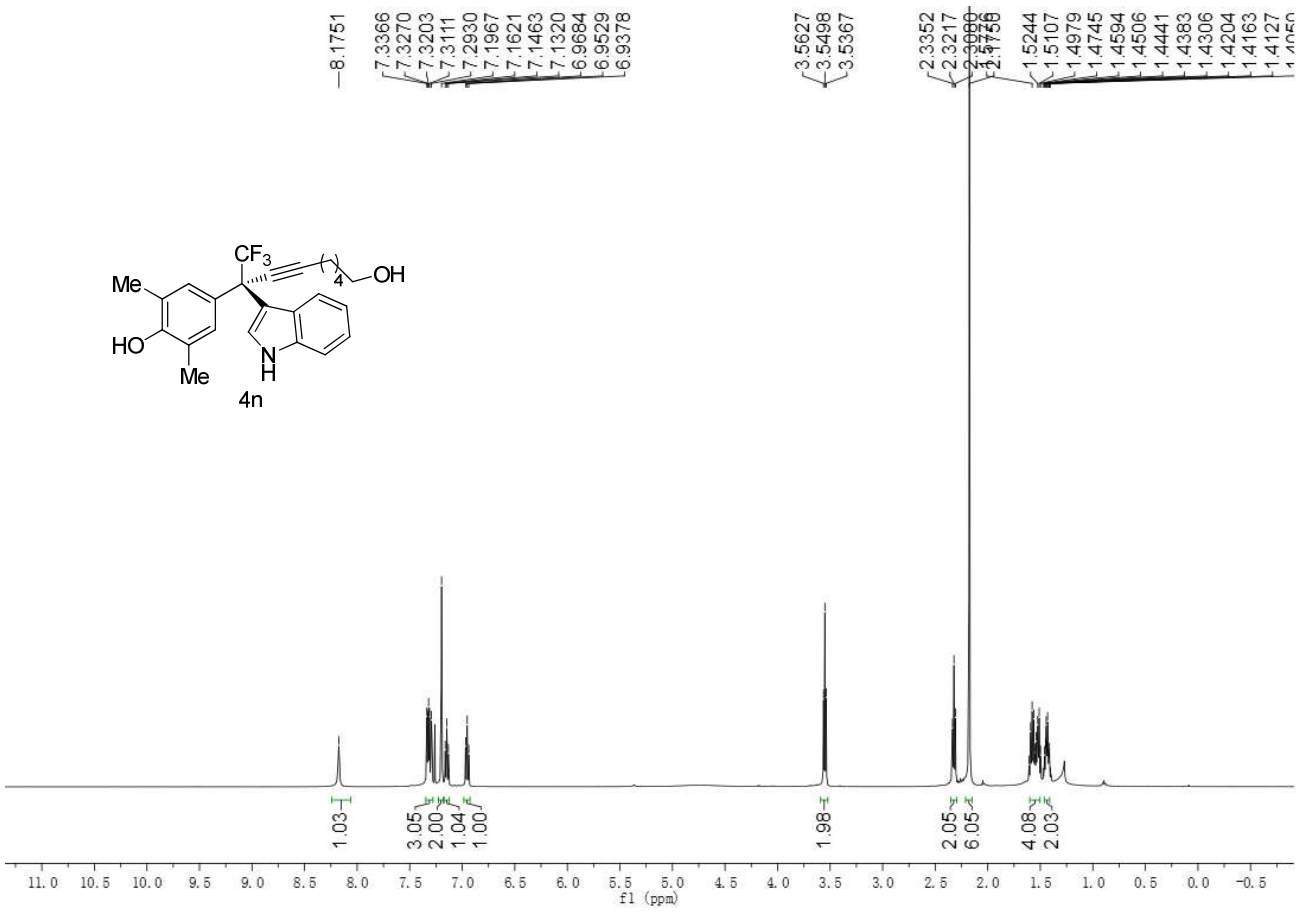
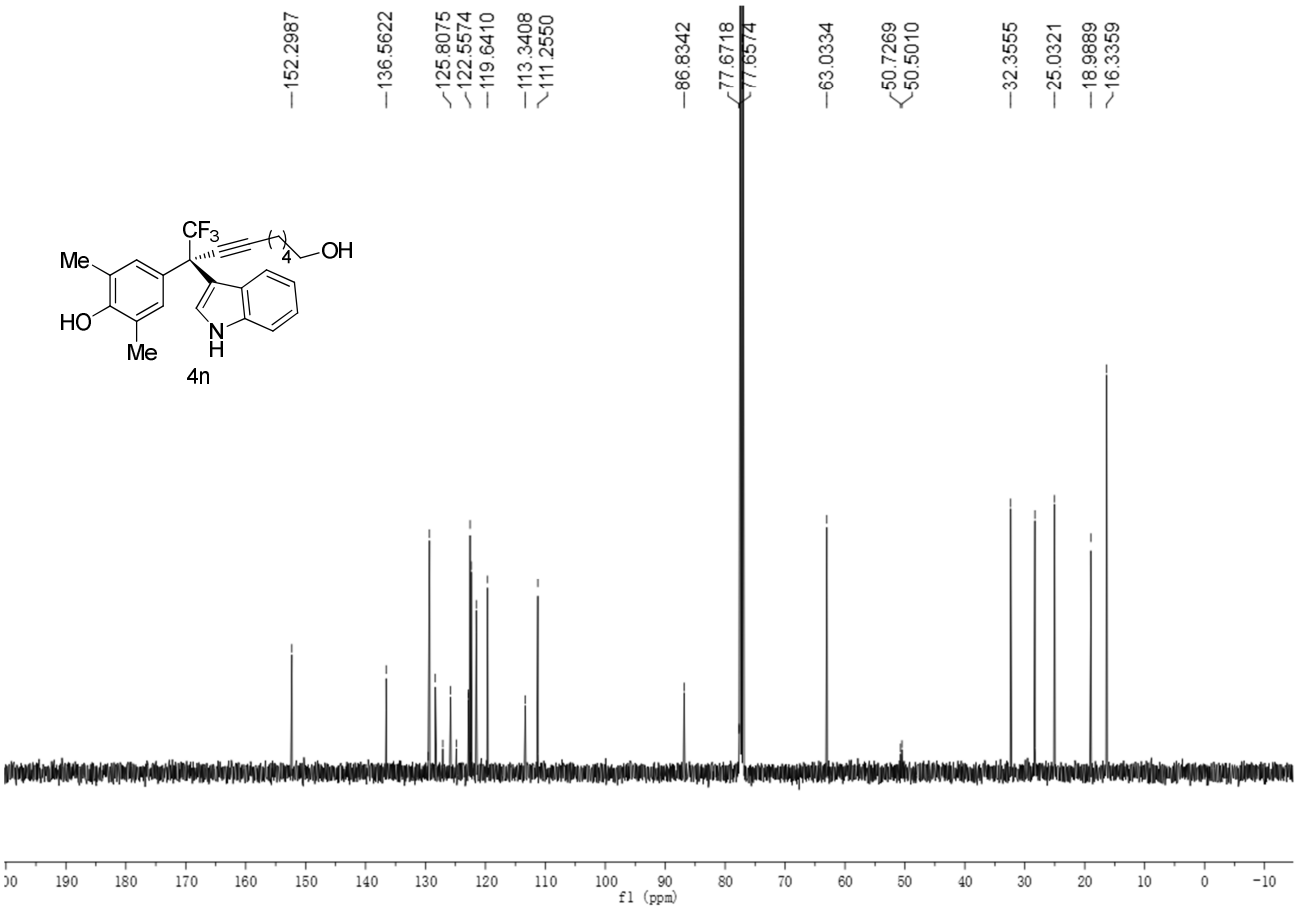
CF3
C6H13
Me
HO
Me
N
H
4m
f1 (ppm)


-70.7612
CF3
C6H13
Me
HO
Me
N
H
4m
f1 (ppm)


8.1751
7.3366
7.3270
7.3203
7.3111
7.2930
7.1967
7.1621
7.1463
7.1320
6.9684
6.9529
6.9378
3.5627
3.5498
3.5367
2.3352
2.3217
1.5244
1.5107
1.4979
1.4745
1.4594
1.4506
1.4441
1.4383
1.4306
1.4204
1.4163
1.4127
CF3
OH
Me
HO
Me
N
H
4n
1.03
3.05
2.00
1.04
1.00
1.98
2.05
6.05
4.08
2.03
f1 (ppm)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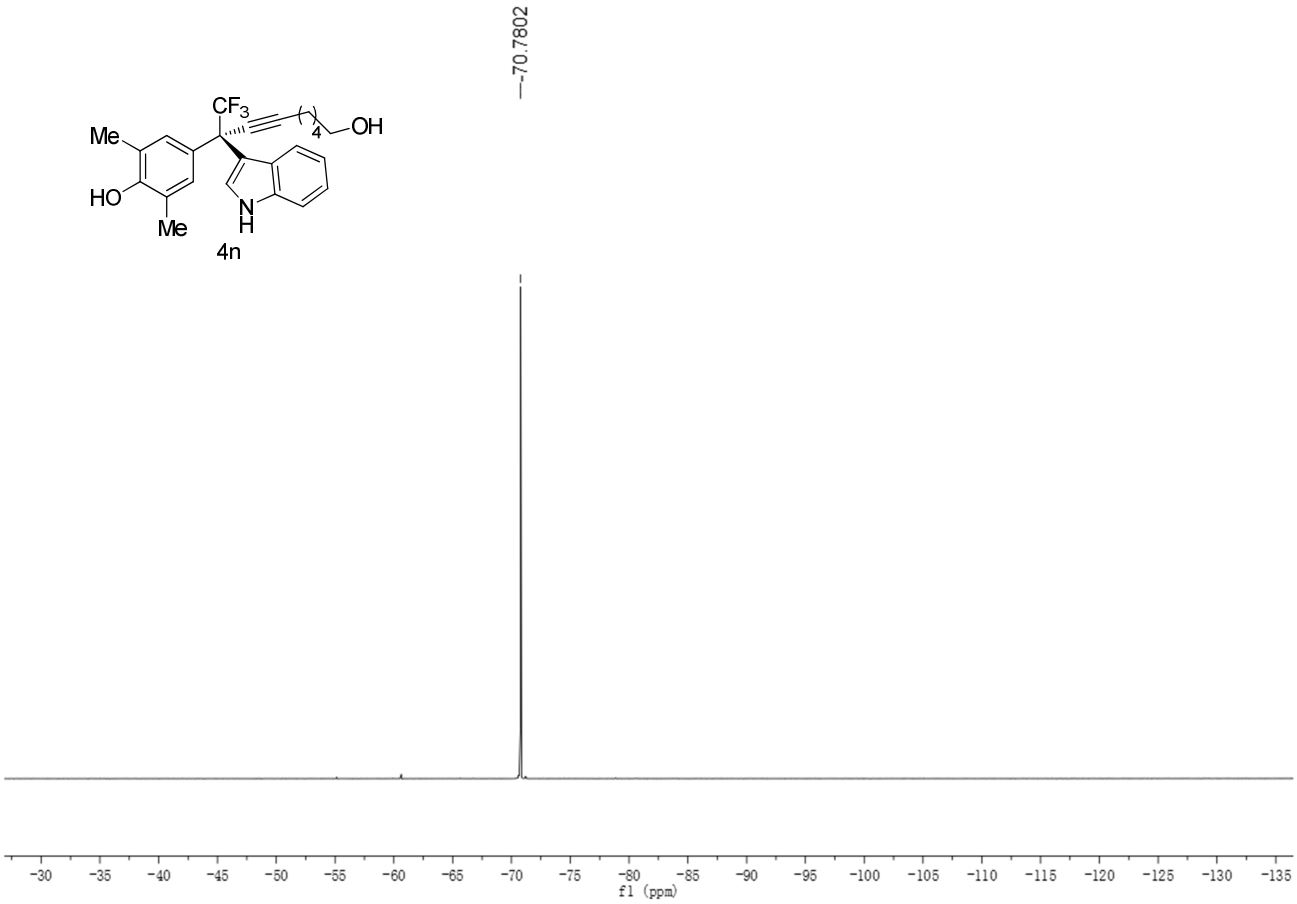
136.5622
125.8075
122.5574
119.6410
113.3408
111.2550
86.8342
77.6718
77.6574
63.0334
50.7269
50.5010
32.3555
25.0321
18.9889
16.3359
CF3
OH
Me
HO
Me
N
H
4n
f1 (ppm)

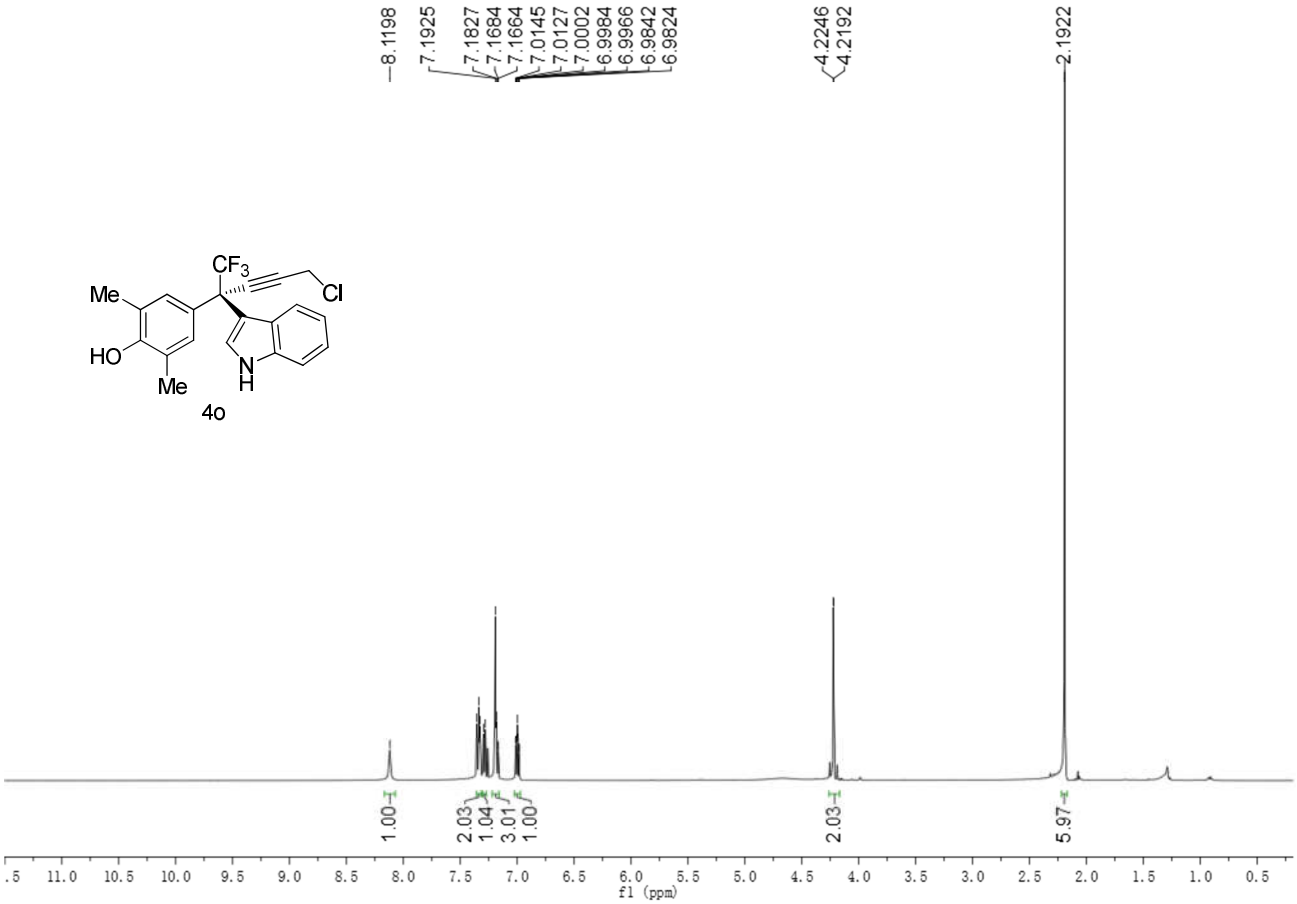
CF3
OH
4
Me
HO
Me
N
H

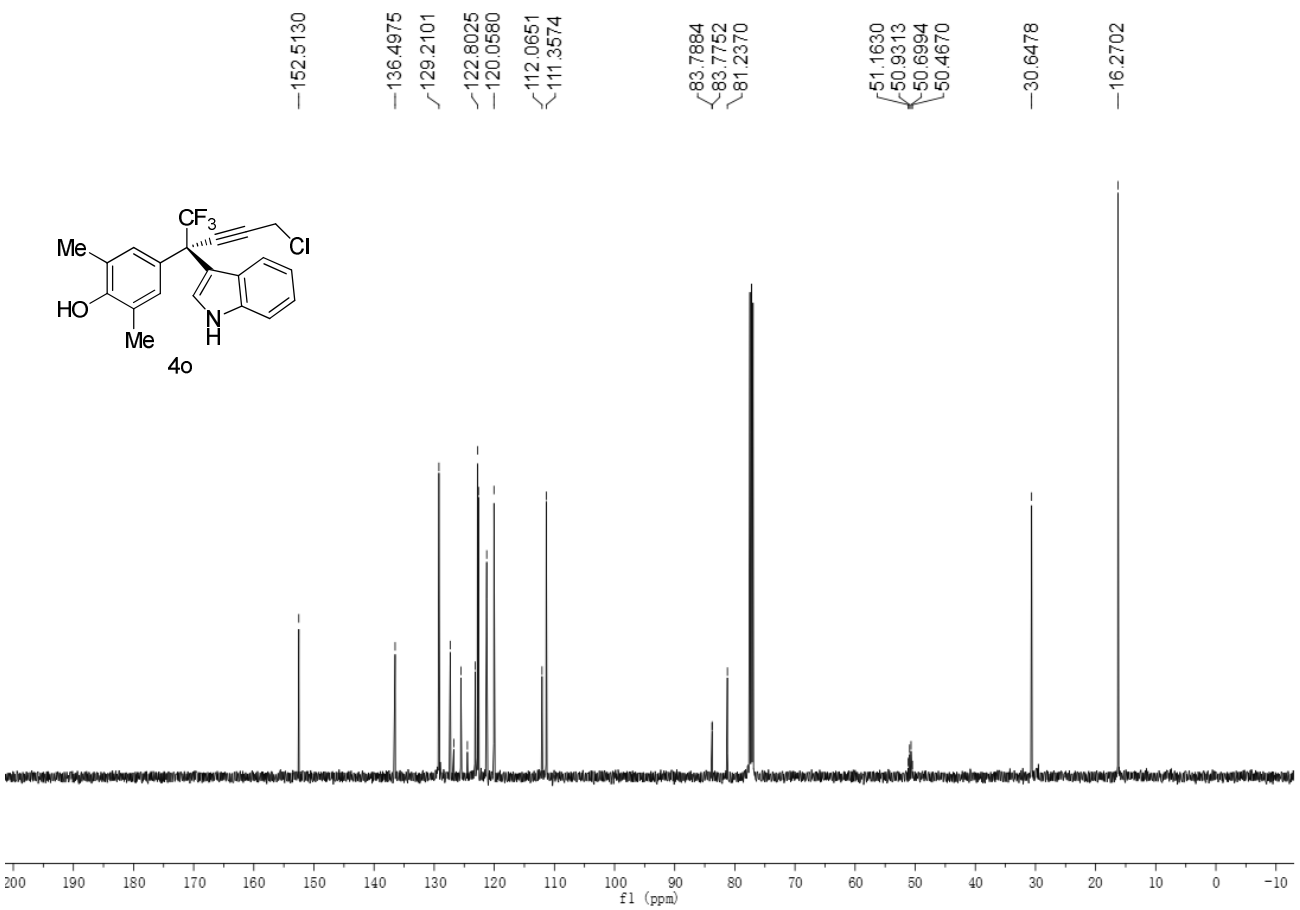
4n

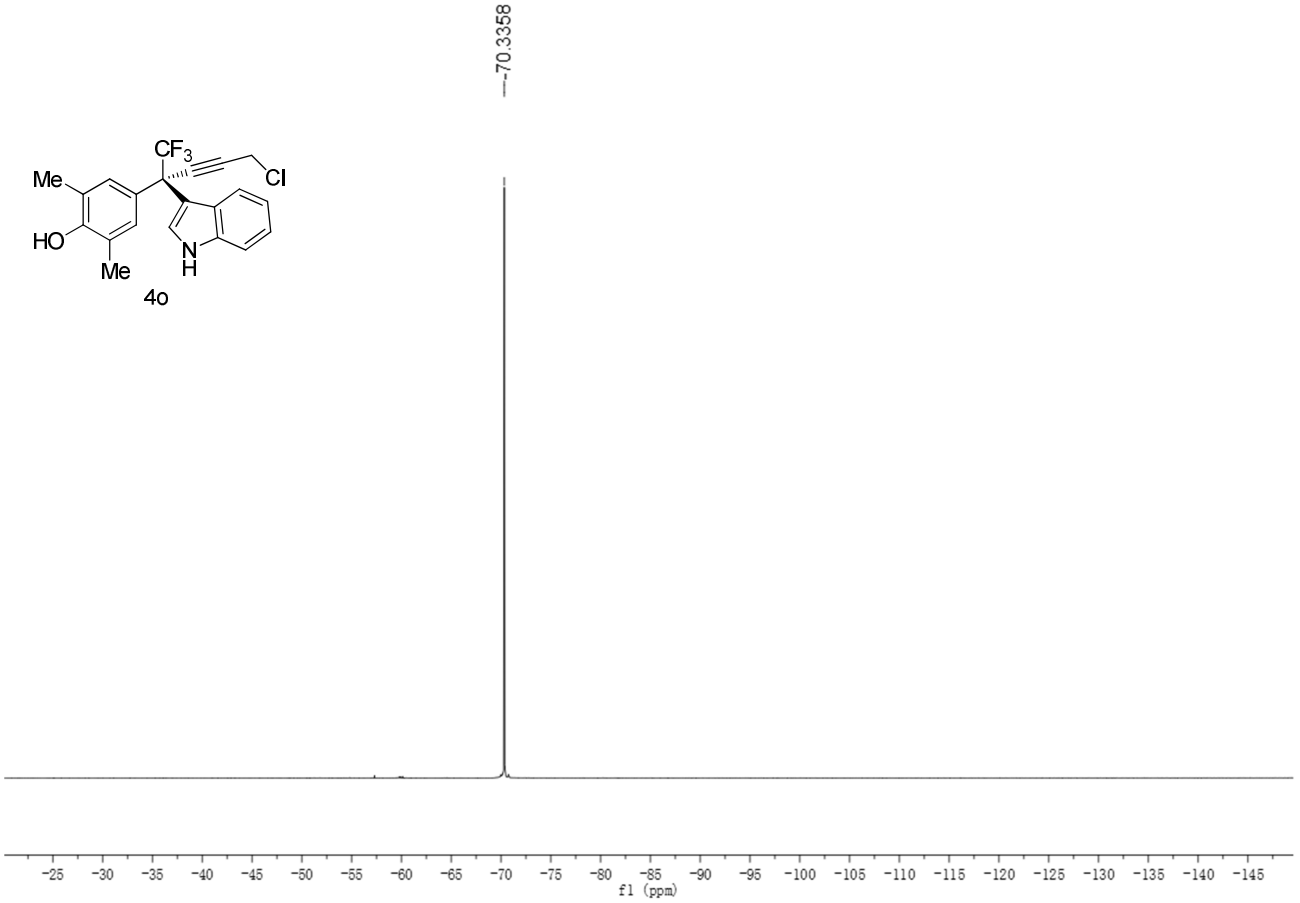

-70.7802
-30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120 -125 -130 -135
f1 (ppm)

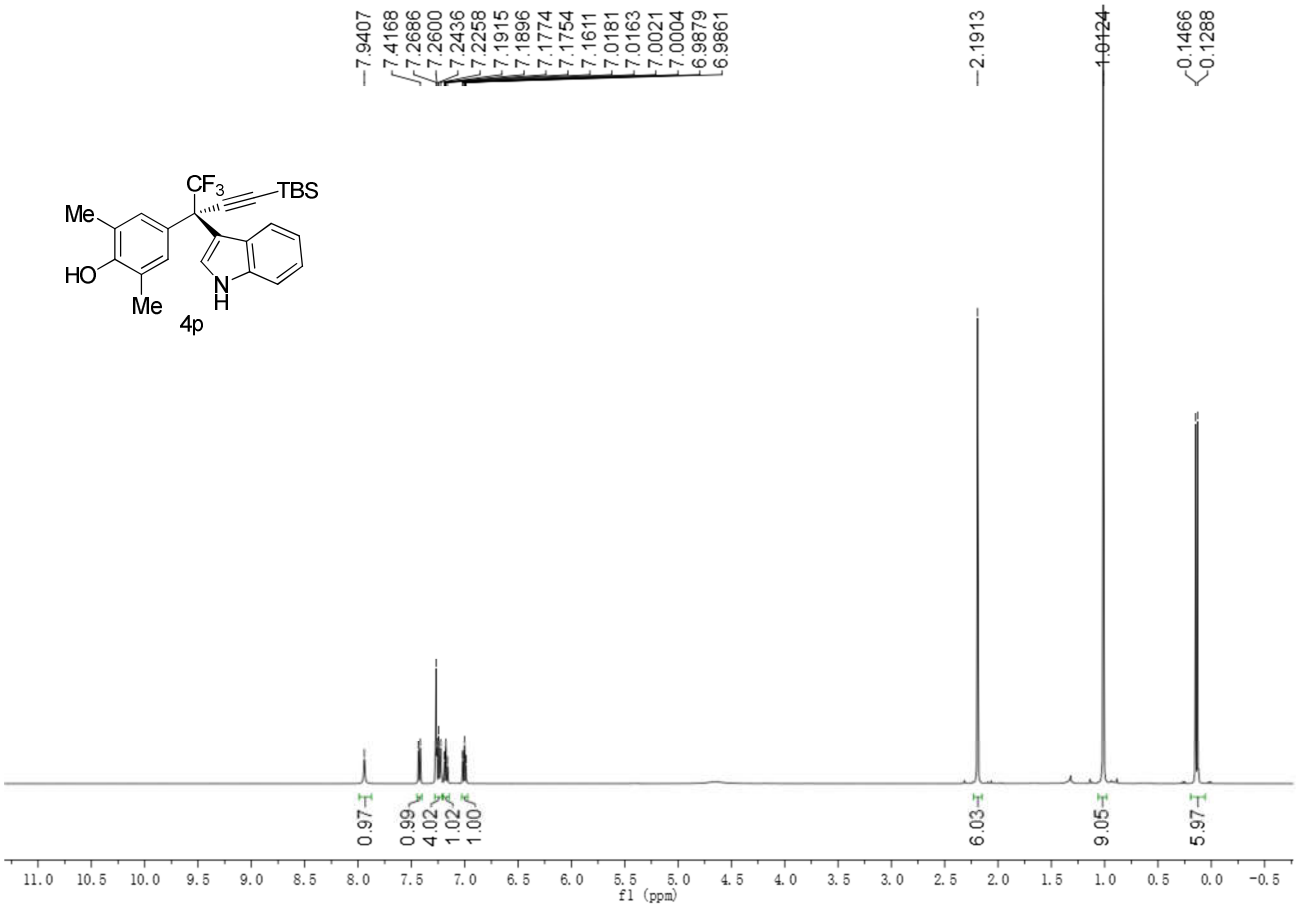
CF3
Cl
Me
HO
Me
N
H

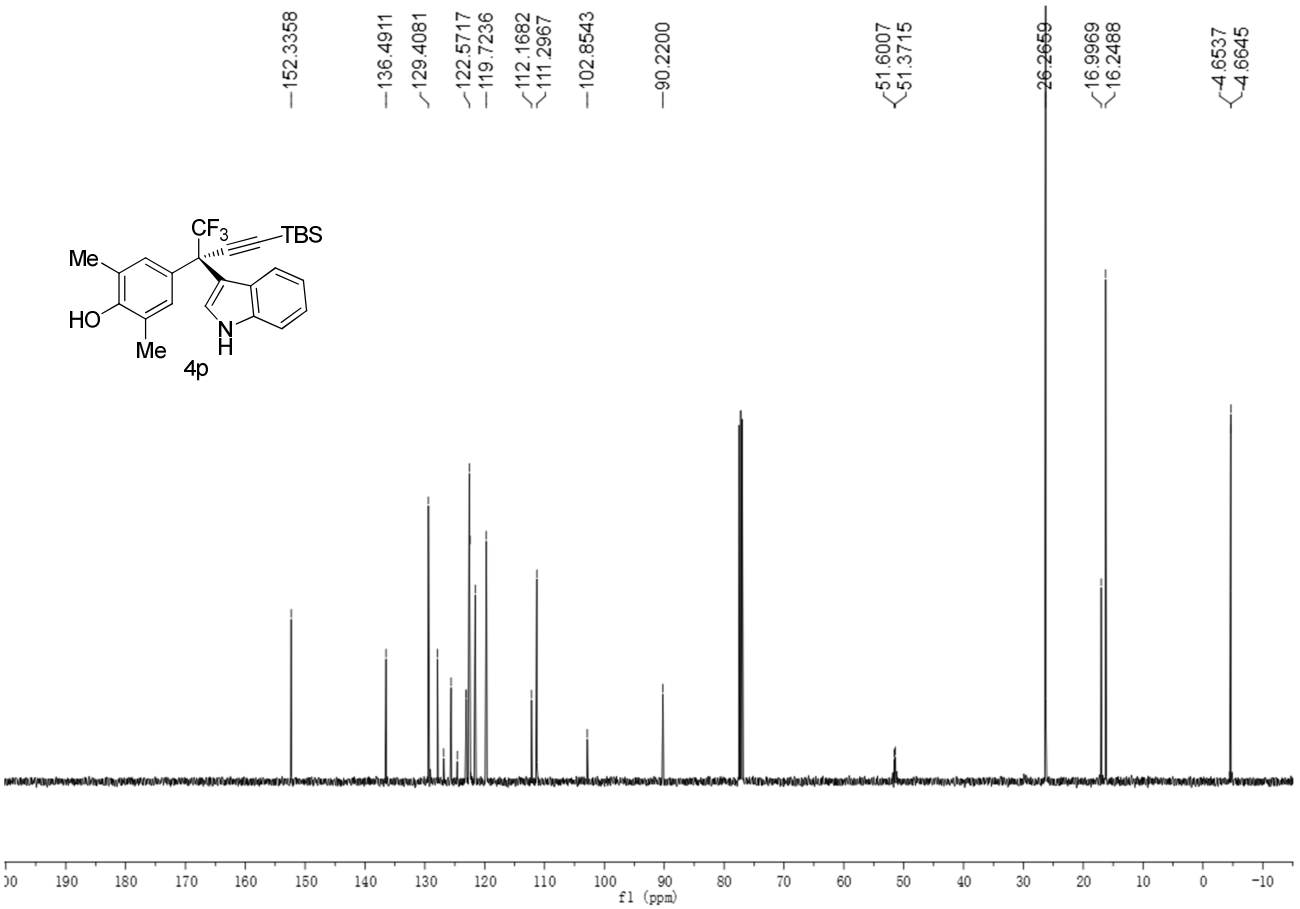
4o


8.1198
7.1925
7.1827
7.1684
7.1664
7.0145
7.0127
7.0002
6.9984
6.9966
6.9842
6.9824
4.2246
4.2192
2.1922
1.00
2.03
1.04
3.01
1.00
2.03
5.97
f1 (ppm)


152.5130
136.4975
129.2101
122.8025
120.0580
112.0651
111.3574
83.7884
83.7752
81.2370
51.1630
50.9313
50.6994
50.4670
30.6478
16.2702
CF3
Cl
Me
HO
Me
N
H
4o
f1 (ppm)

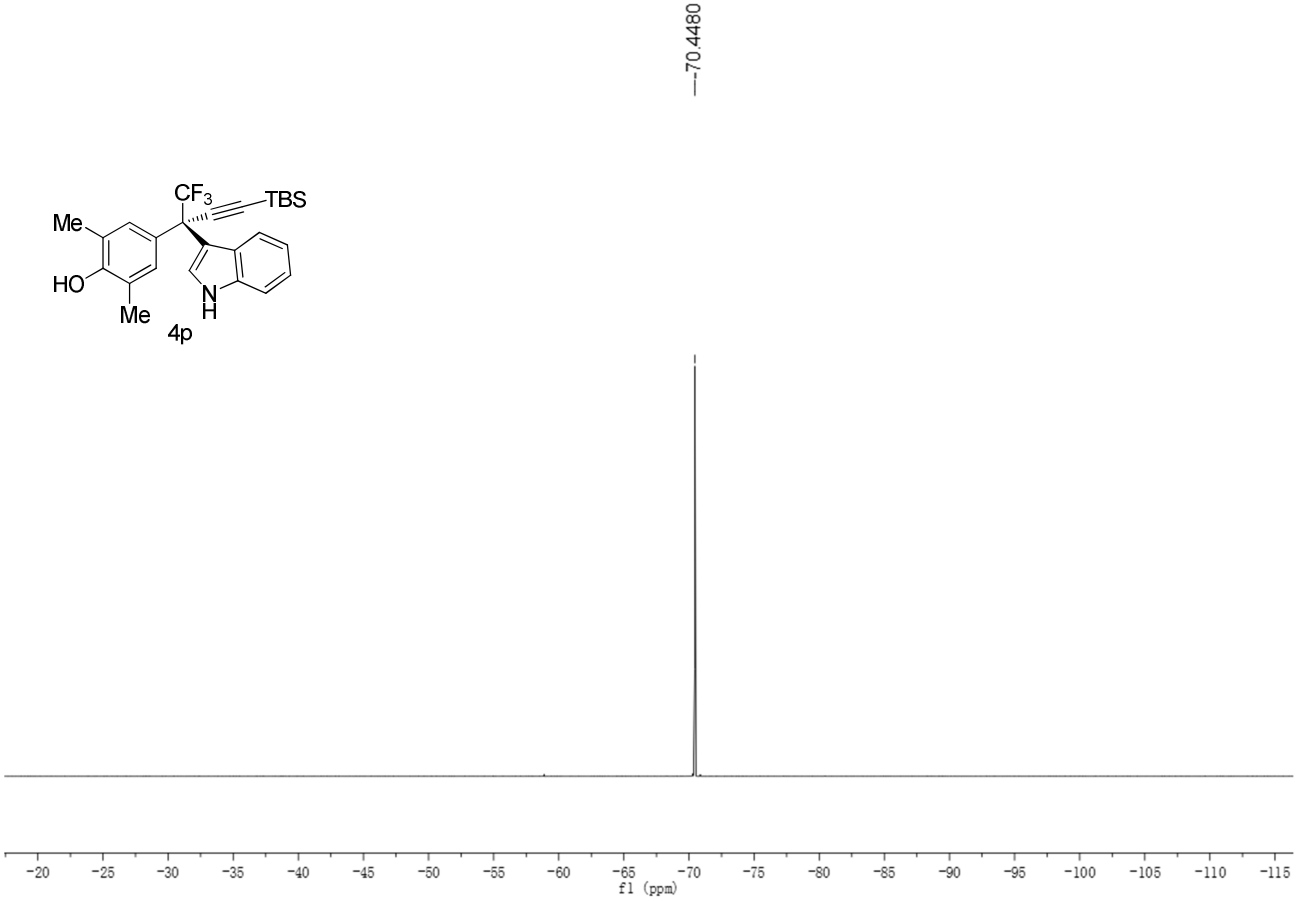

-70.3358
CF3
Cl
Me
HO
Me
N
H
4o
f1 (ppm)


7.9407
7.4168
7.2686
7.2600
7.2436
7.2258
7.1915
7.1896
7.1774
7.1754
7.1611
7.0181
7.0163
7.0021
7.0004
6.9879
6.9861
2.1913
1.0124
0.1466
0.1288
CF3
TBS
Me
HO
Me
N
H
4p
0.97
0.99
4.02
1.02
1.00
6.03
9.05
5.97
f1 (ppm)


152.3358
136.4911
129.4081
122.5717
119.7236
112.1682
111.2967
102.8543
90.2200
51.6007
51.3715
26.2659
16.9969
16.2488
4.6537
4.6645
CF3
TBS
Me
HO
Me
N
H
4p
f1 (ppm)

CF3
TBS
Me
HO
Me
N
H

4p


-70.4480
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)


7.3645
7.3481
7.3151
7.3034
7.2991
7.2848
7.2674
7.2602
7.2583
7.2490
7.2455
7.2353
7.2318
7.1120
7.0945
7.0646
7.0501
7.0344
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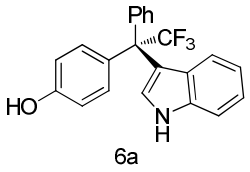
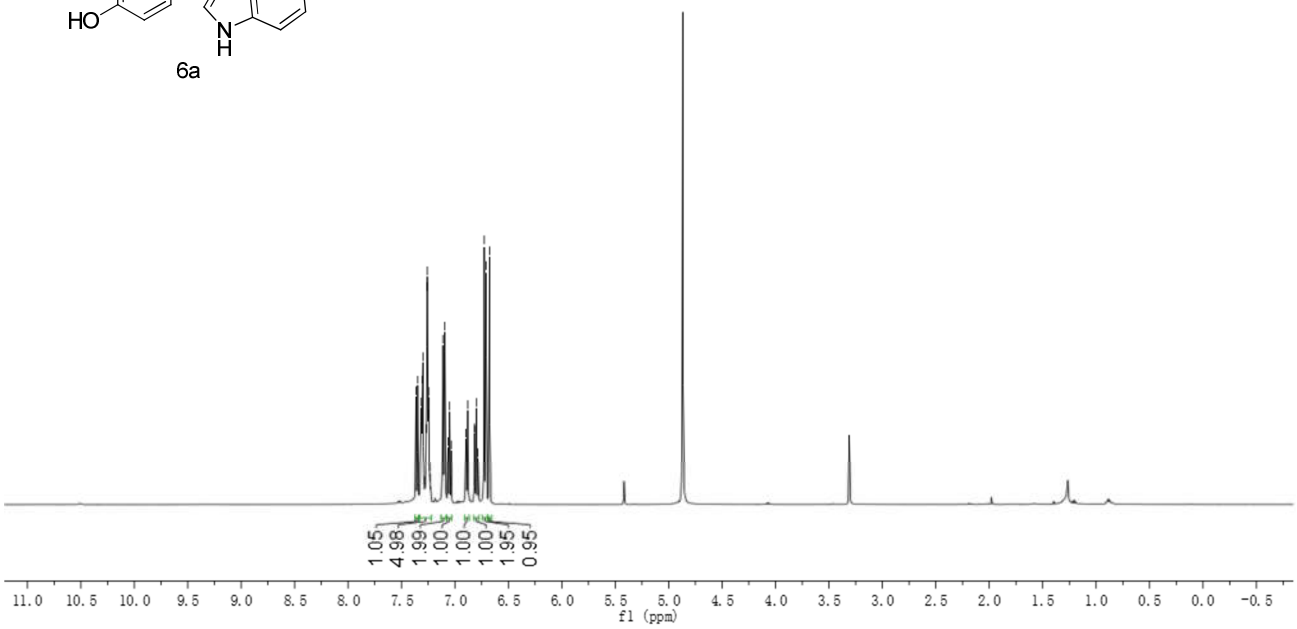
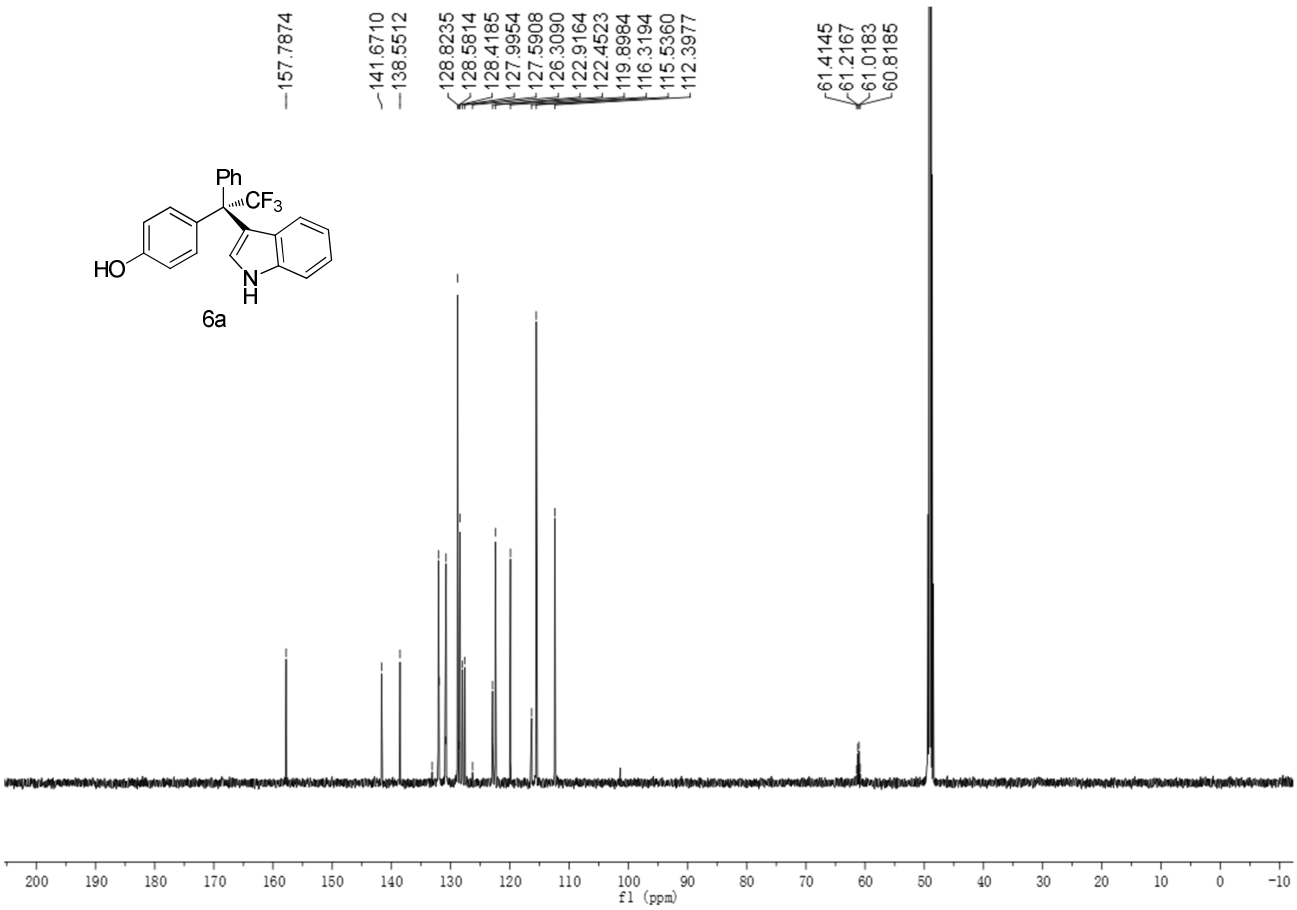
6.8801
6.8154
6.8142
6.7996
6.7851
6.7257
6.7080
6.6762


Ph
CF3
HO
N
H

6a


1.05
4.98
1.99
1.00
1.00
1.00
1.95
0.95
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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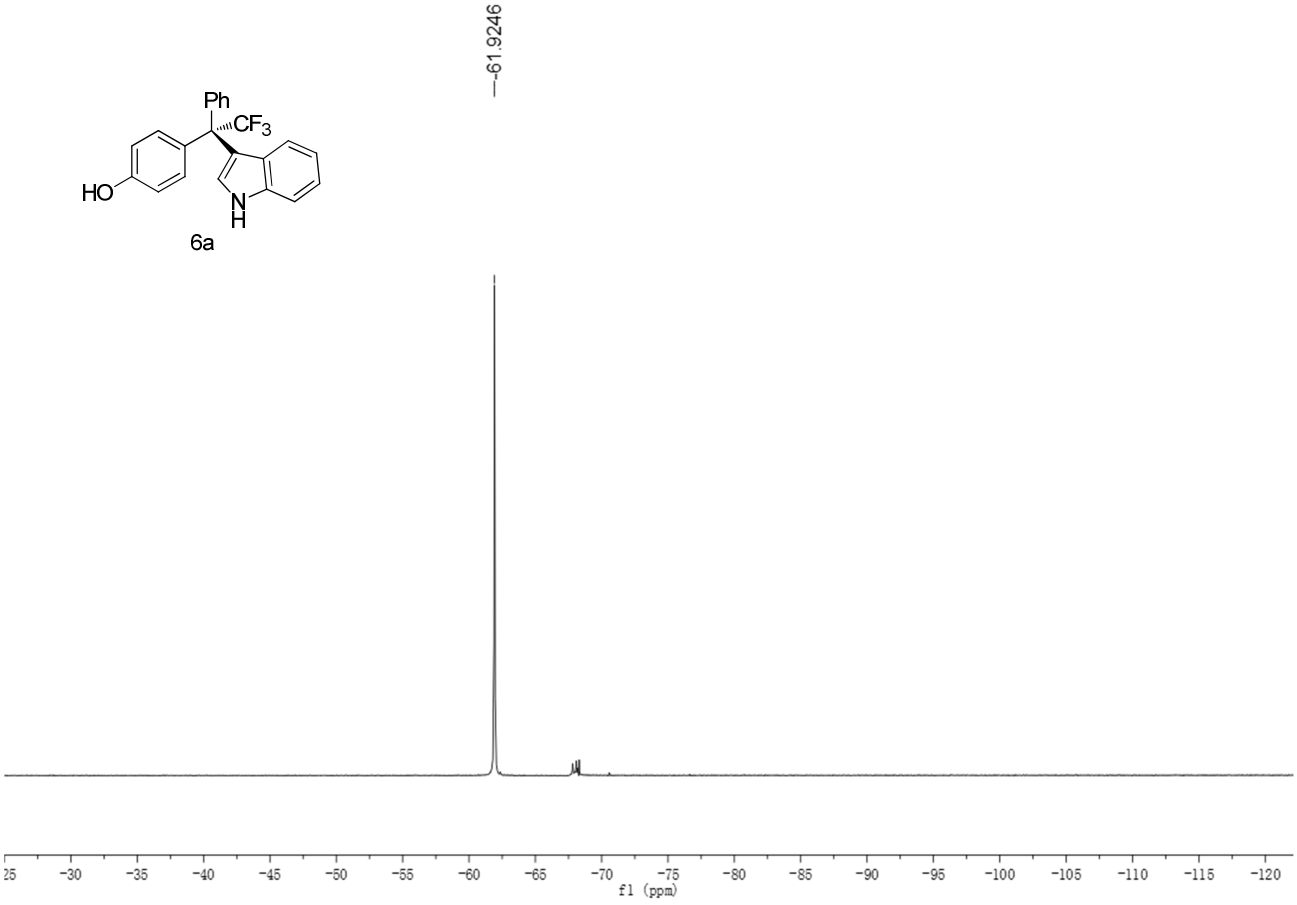
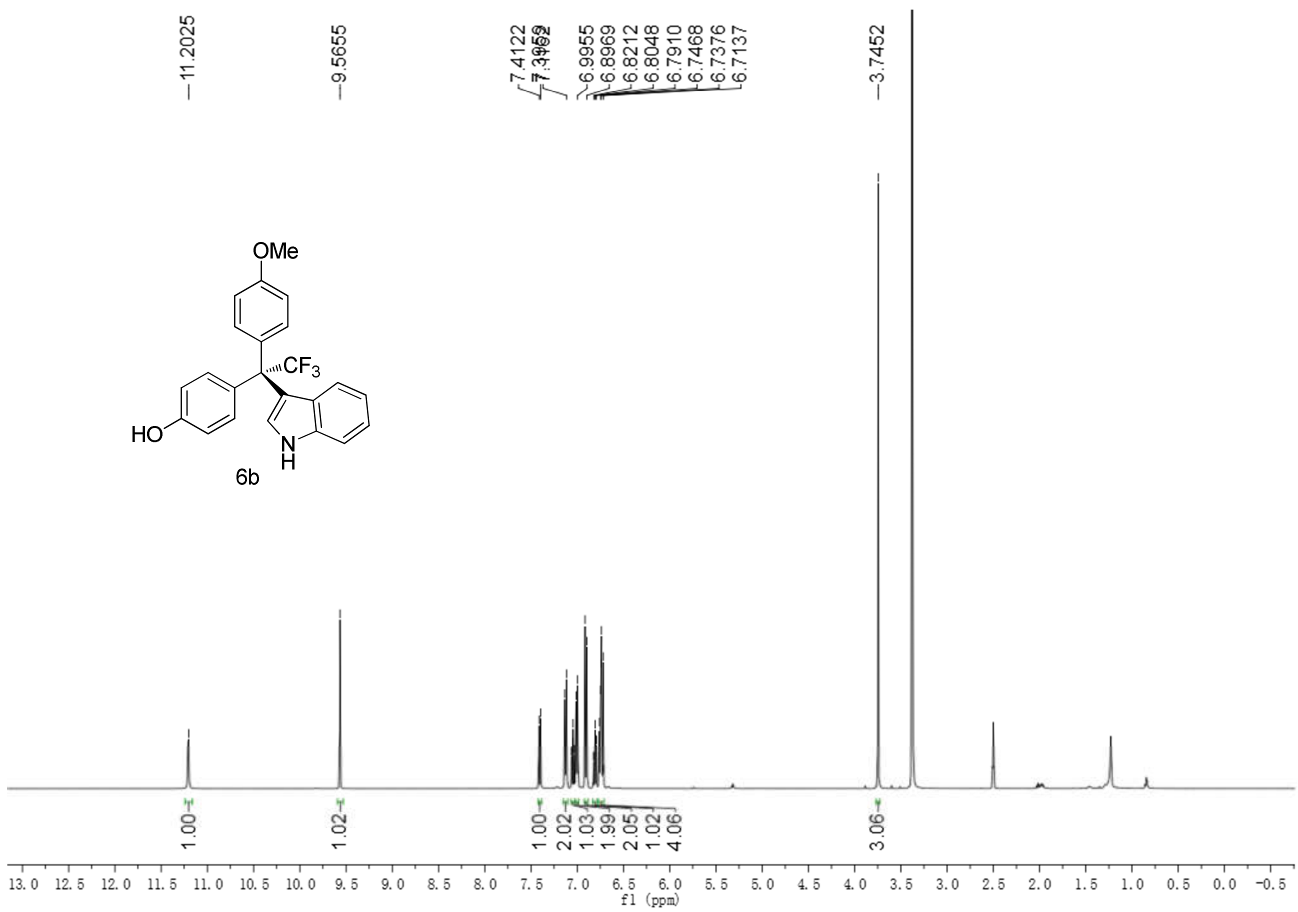
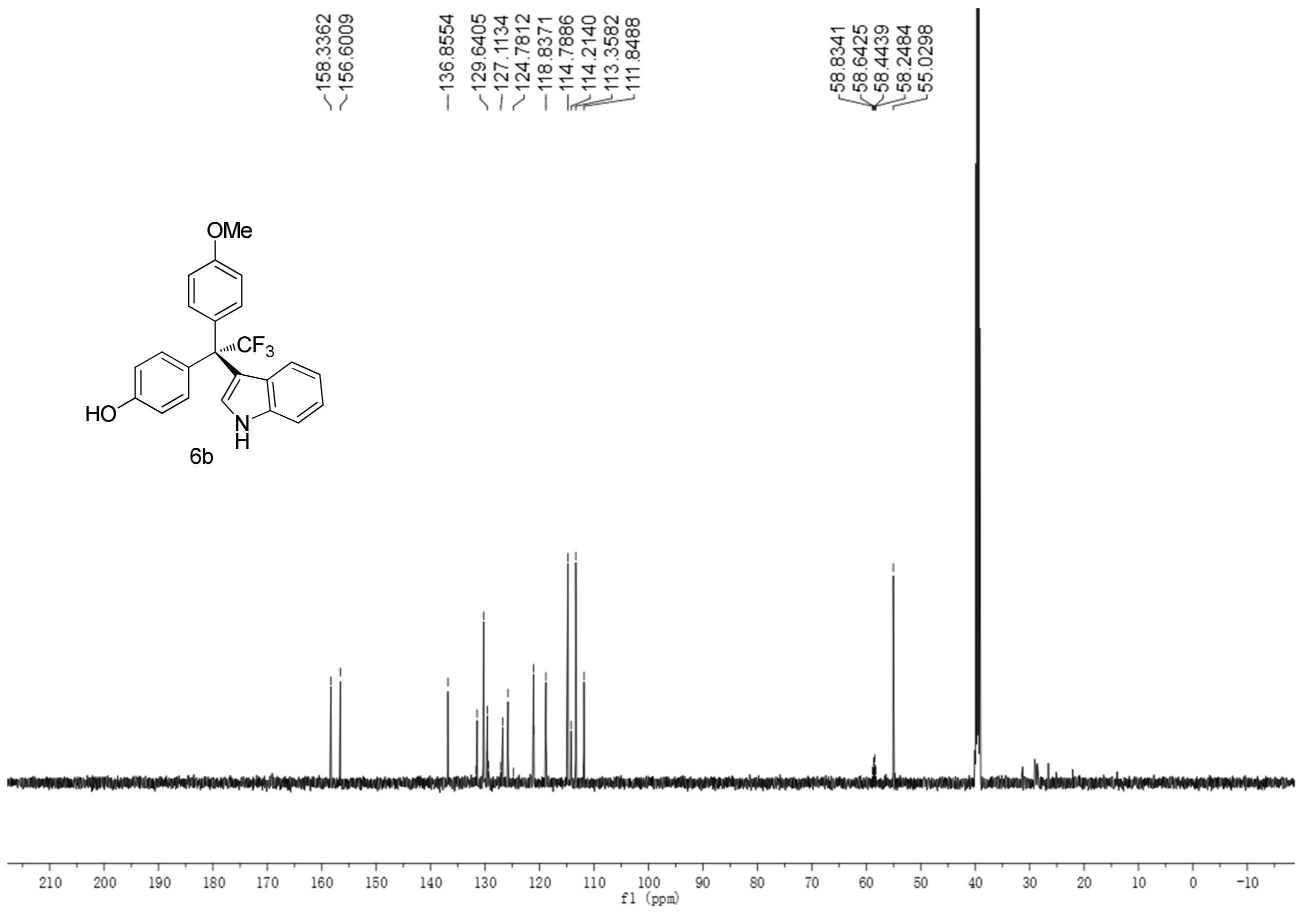
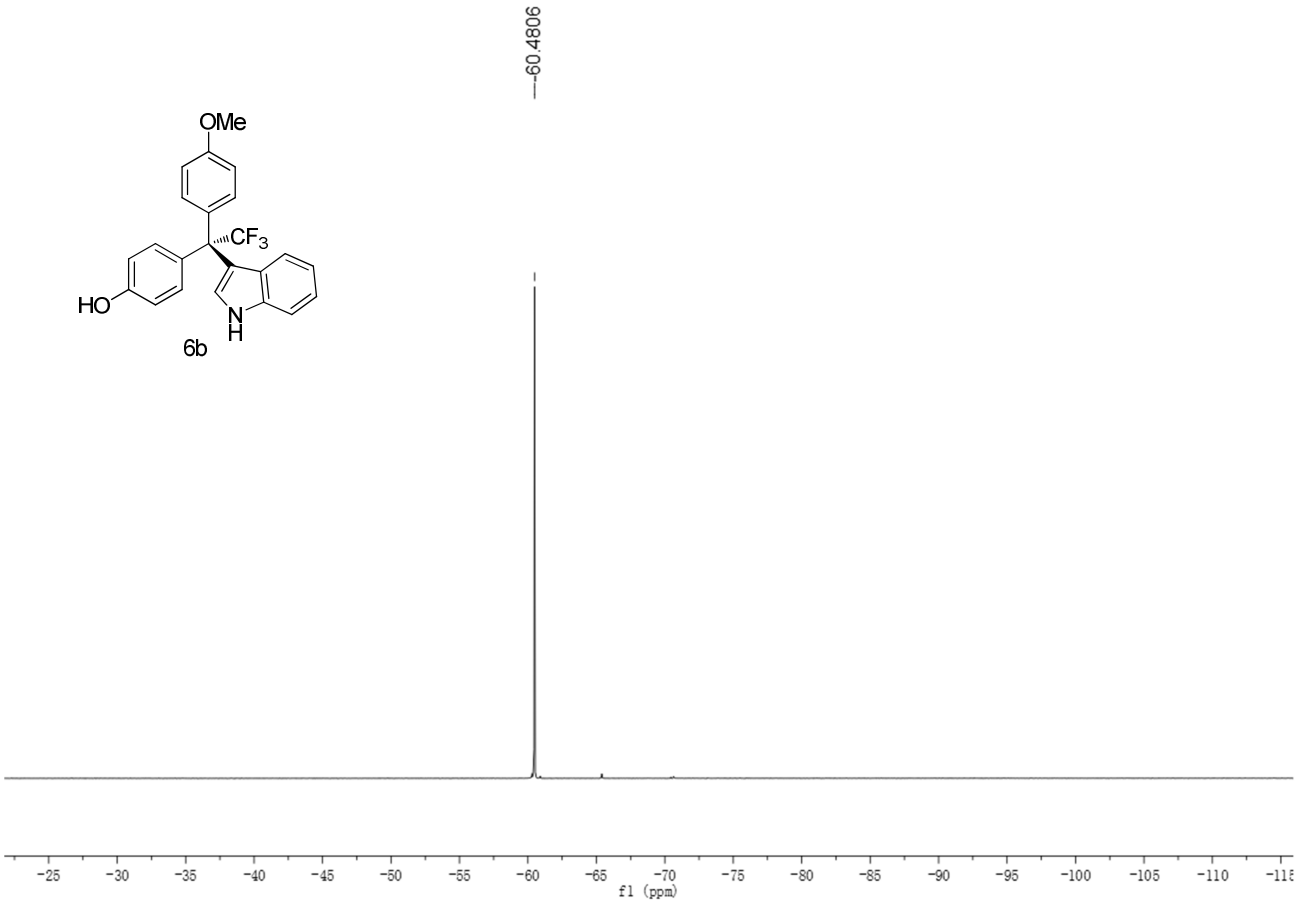
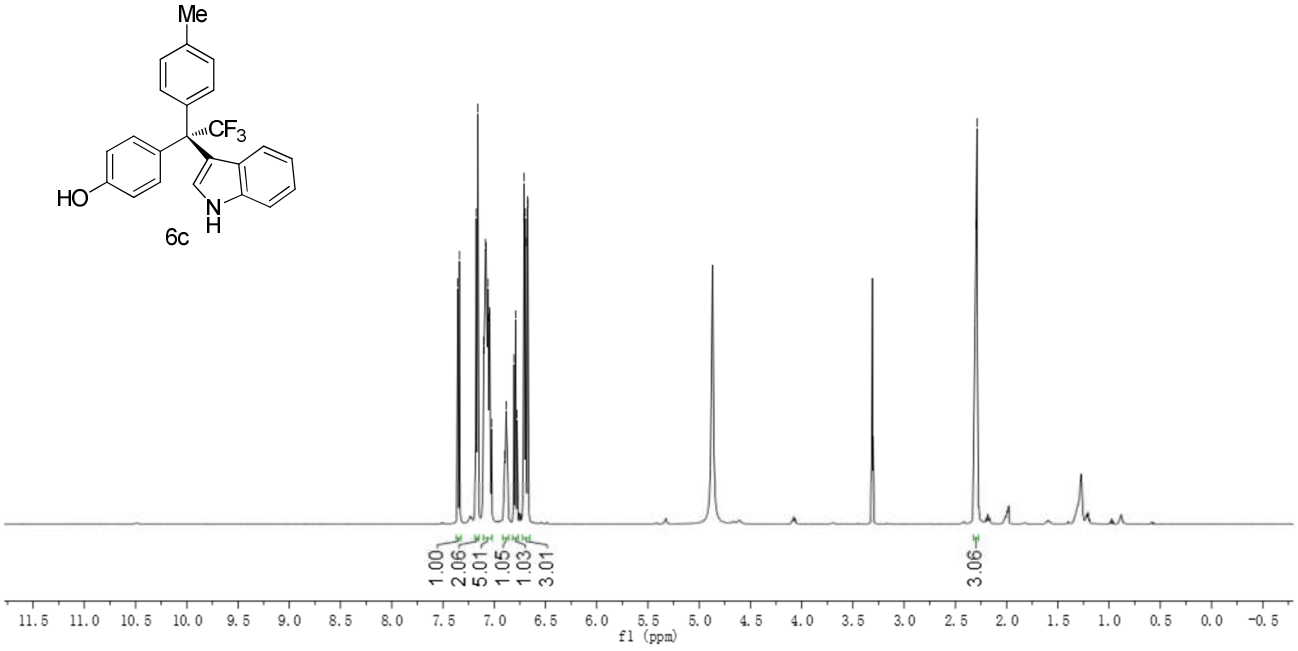
141.6710
138.5512
128.8235
128.5814
128.4185
127.9954
127.5908
126.3090
122.9164
122.4523
119.8984
116.3194
115.5360
112.3977
61.4145
61.2167
61.0183
60.8185
Ph
CF3
HO
N
H
6a
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

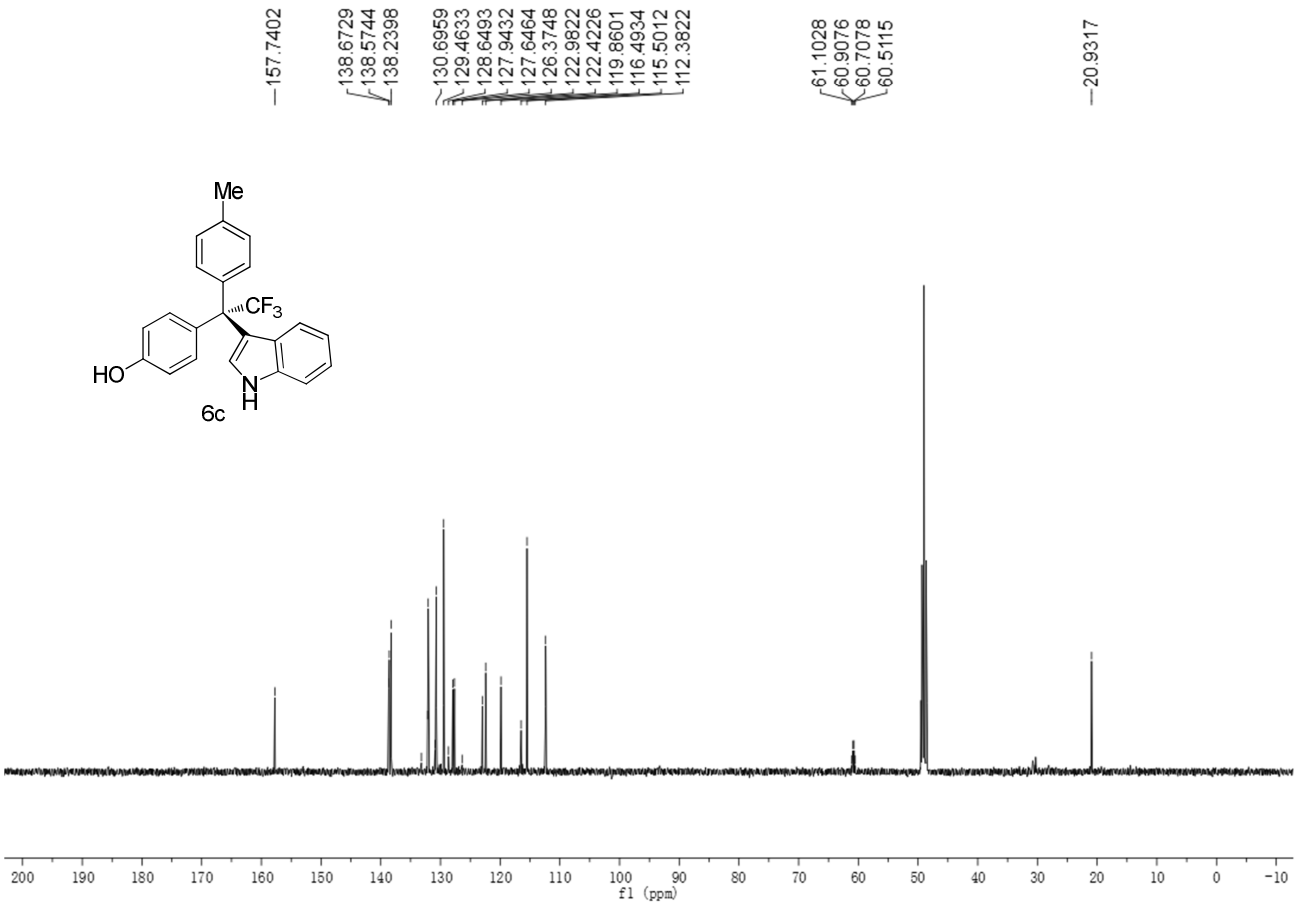

-61.9246
Ph
CF3
HO
N
H
6a
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120
f1 (ppm)

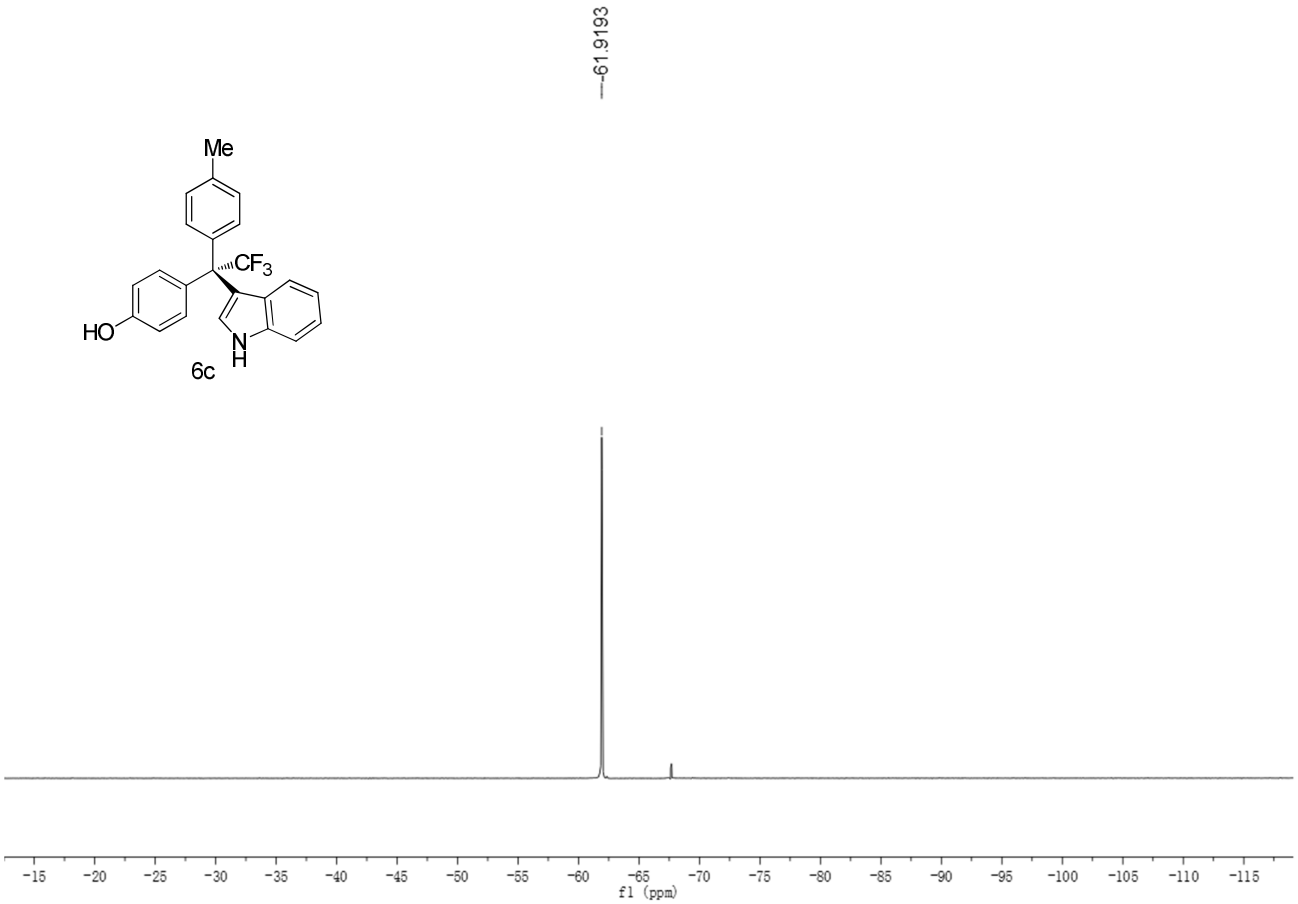

11.2025
9.5655
7.4122
6.9955
6.8969
6.8212
6.8048
6.7910
6.7468
6.7376
6.7137
3.7452
OMe
CF3
HO
N
H
6b
1.00
1.02
1.00
2.02
1.03
1.99
2.05
1.02
4.06
3.06
f1 (ppm)

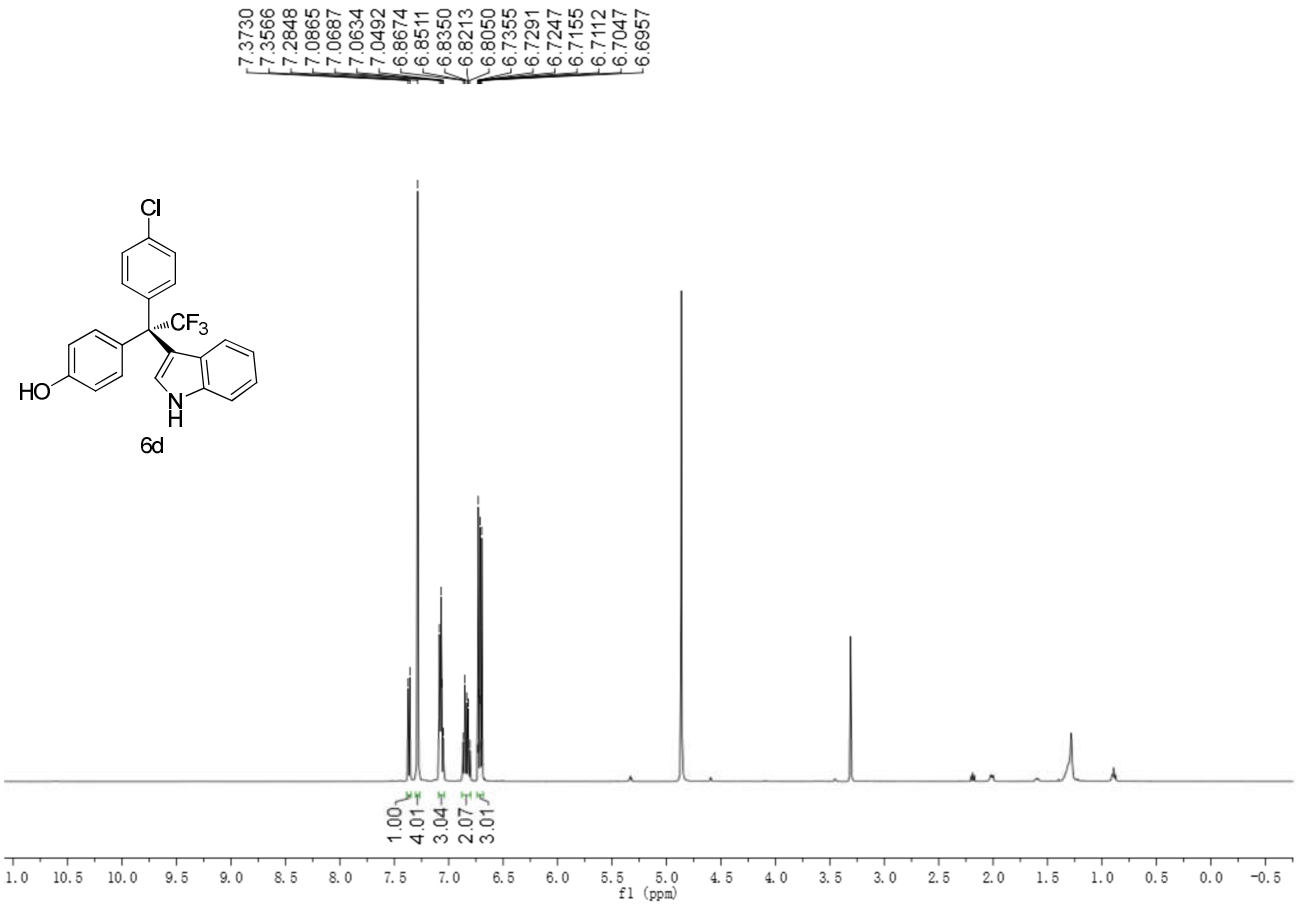

158.3362
156.6009
136.8554
129.6405
127.1134
124.7812
118.8371
114.7886
114.2140
113.3582
111.8488
58.8341
58.6425
58.4439
58.2484
55.0298
OMe
CF3
HO
N
H
6b
f1 (ppm)

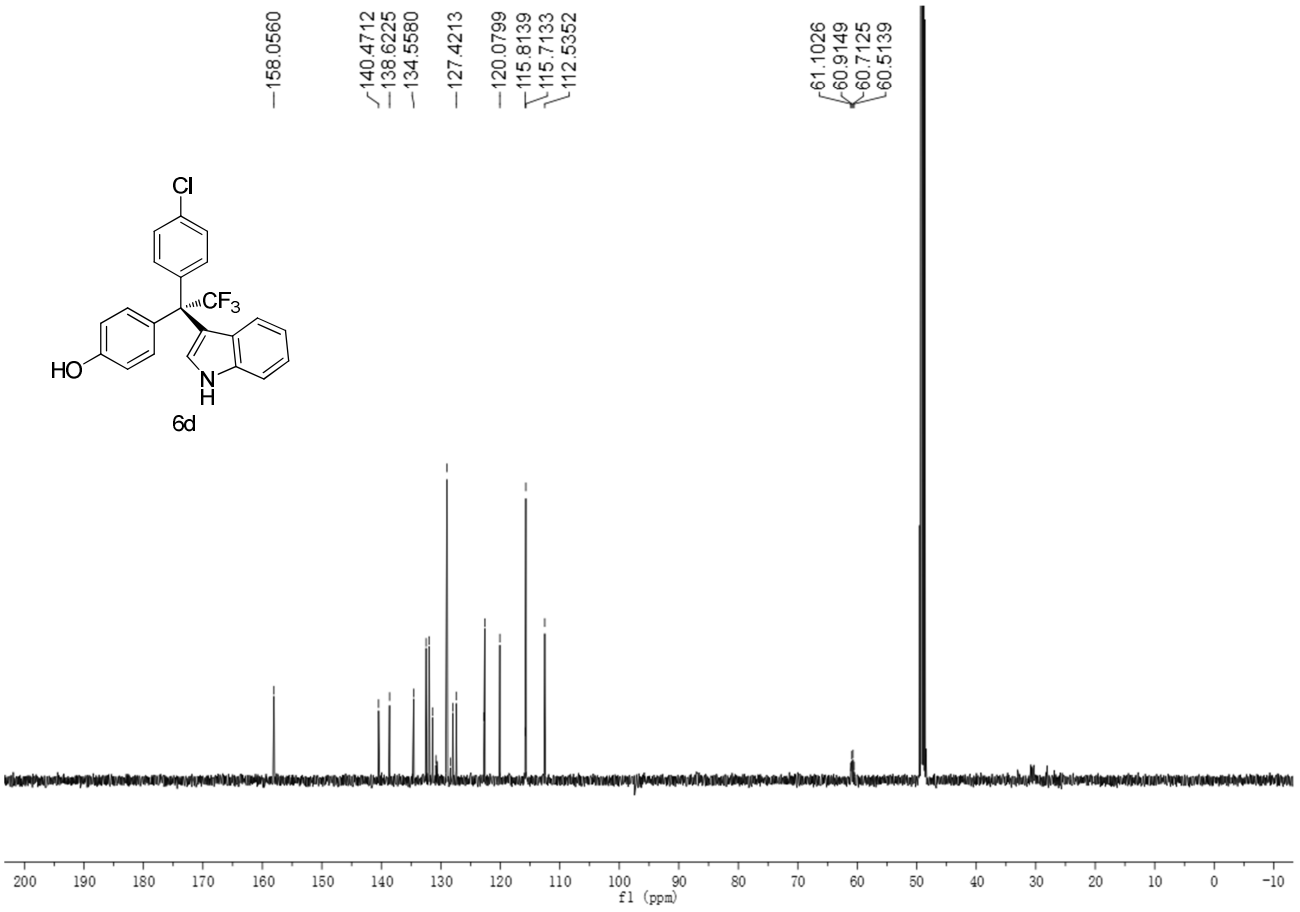

-60.4806
OMe
CF3
HO
N
H
6b
-25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110
f1 (ppm)
7.3560
7.3397
7.1764
7.1600
7.1021
7.0852
7.0788
7.0623
7.0571
7.0454
7.0431
7.0265
6.8983
6.8838
6.8073
6.7916
6.7769
6.7110
6.7083
6.6934
6.6905
6.6730
6.6708
2.2987
2.2888


Me
CF3
HO
N
H
6c
1.00
2.06
5.01
1.05
1.03
3.01
3.06
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


157.7402
138.6729
138.5744
138.2398
130.6959
129.4633
128.6493
127.9432
127.6464
126.3748
122.9822
122.4226
119.8601
116.4934
115.5012
112.3822
61.1028
60.9076
60.7078
60.5115
20.9317
Me
CF3
HO
N
H
6c
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

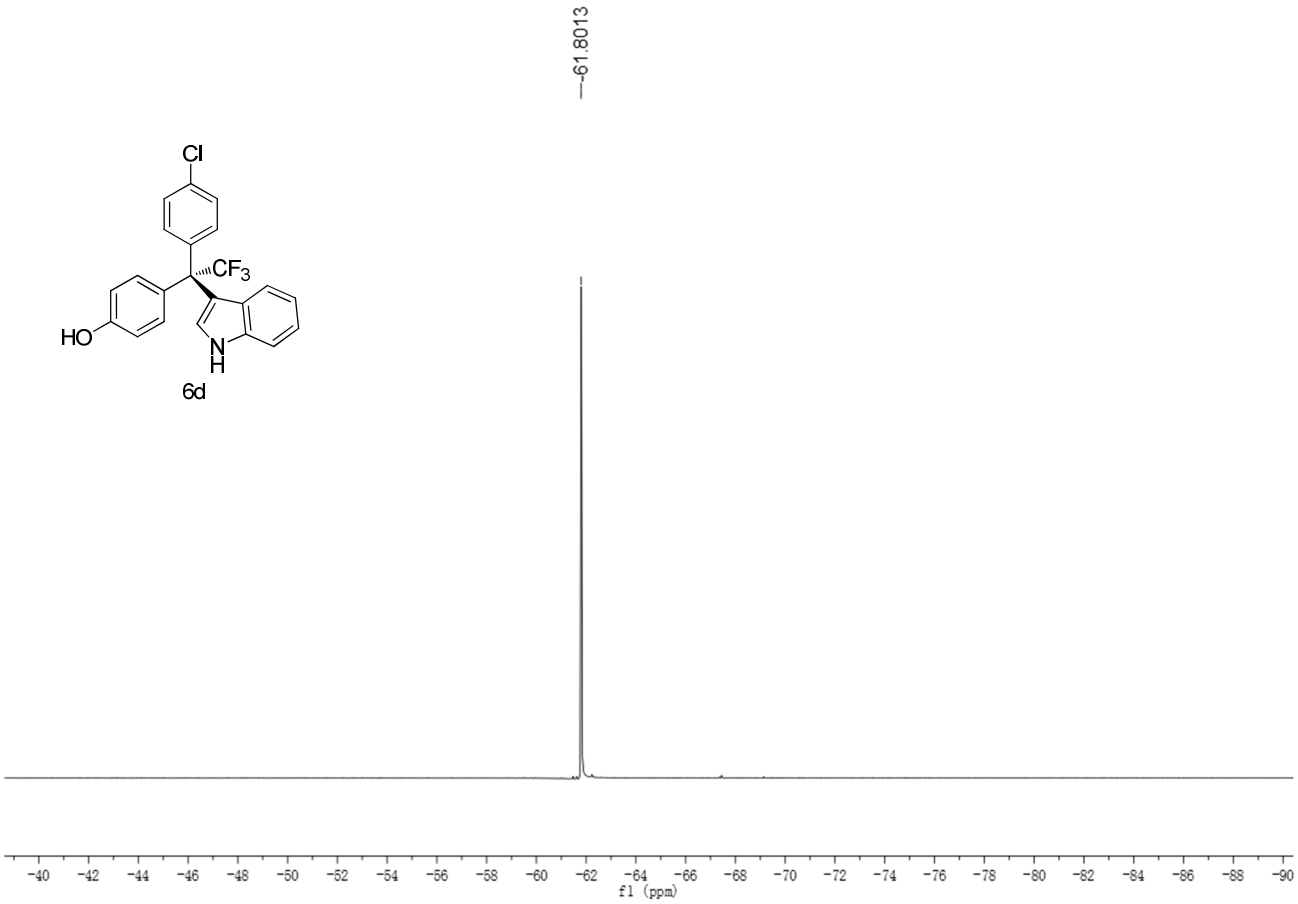

-61.9193
Me
CF3
HO
N
H
6c
-15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)


7.3730
7.3566
7.2848
7.0865
7.0687
7.0634
7.0492
6.8674
6.8511
6.8350
6.8213
6.8050
6.7355
6.7291
6.7247
6.7155
6.7112
6.7047
6.6957
Cl
CF3
HO
N
H
6d
1.00
4.01
3.04
2.07
3.01
f1 (ppm)


158.0560
140.4712
138.6225
134.5580
127.4213
120.0799
115.8139
115.7133
112.5352
61.1026
60.9149
60.7125
60.5139
Cl
CF3
HO
N
H
6d
f1 (ppm)

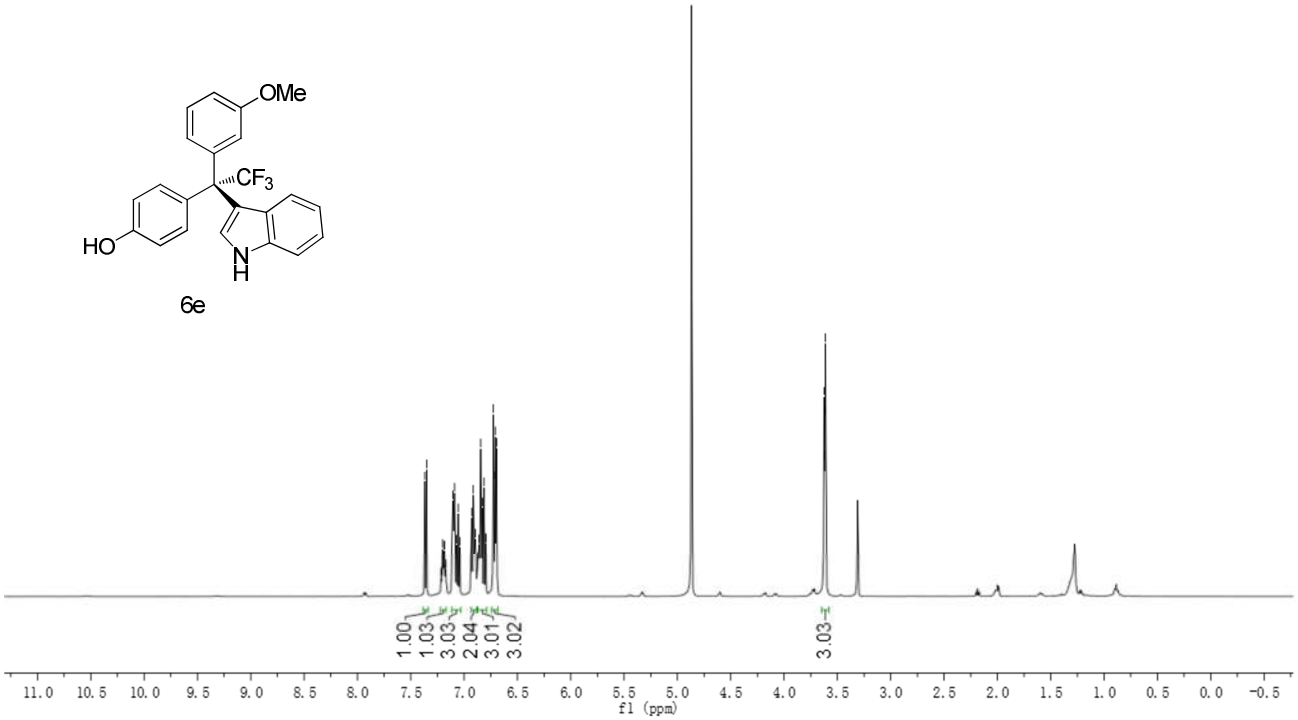
Cl
CF3
HO
N
H

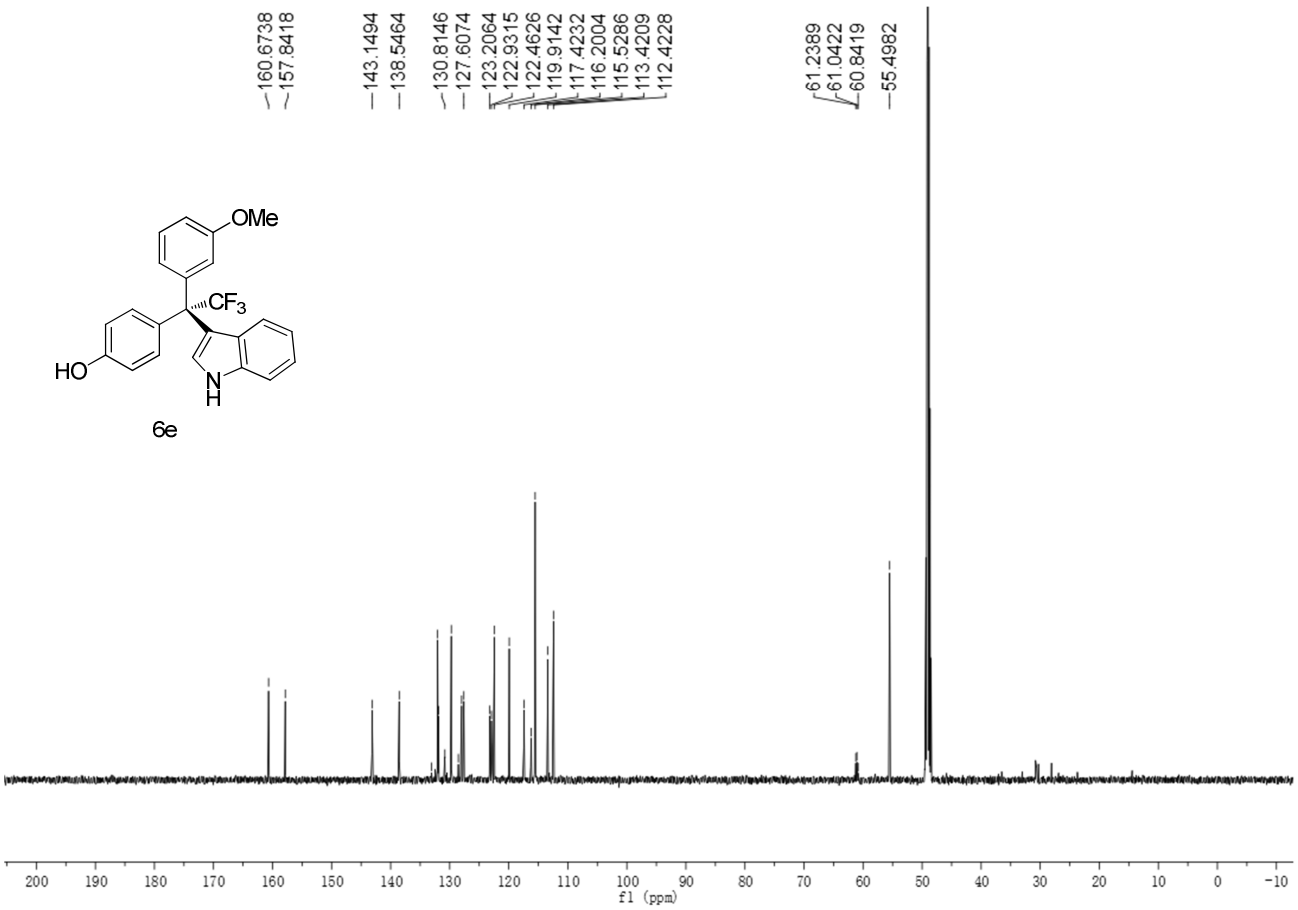
6d

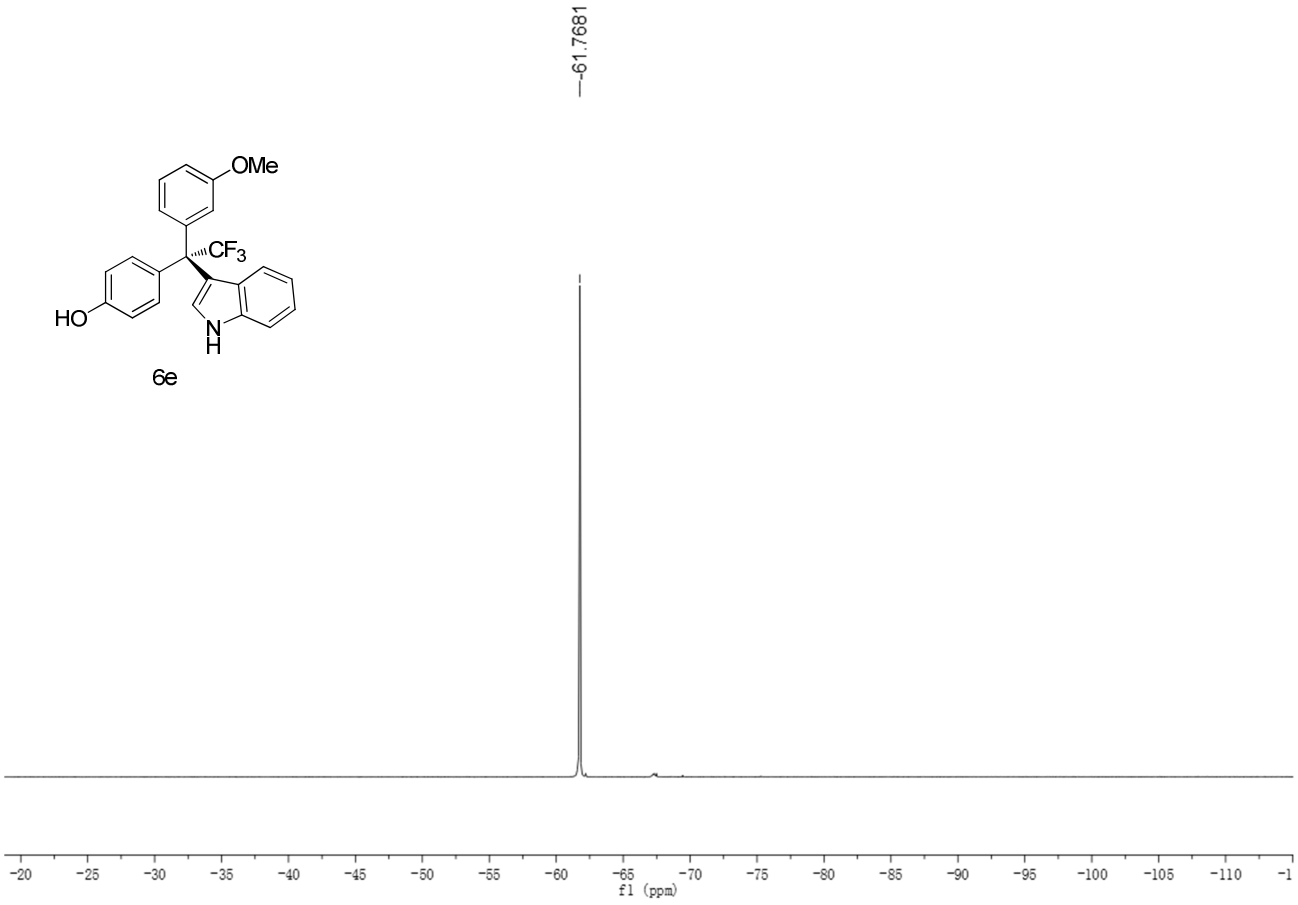

-61.8013
-40 -42 -44 -46 -48 -50 -52 -54 -56 -58 -60 -62 -64 -66 -68 -70 -72 -74 -76 -78 -80 -82 -84 -86 -88 -90
f1 (ppm)
7.3513
7.2169
7.2081
7.2010
7.1924
7.1866
7.1853
7.1766
7.1713
7.1060
7.0892
7.0709
7.0550
7.0406
6.9299
6.9136
6.8941
6.8820
6.8736
6.8593
6.8443
6.8271
6.8126
6.7980
6.7970
6.7253
6.7112
6.7079
6.6954
3.6258
3.6221
3.6173
3.6119

OMe
CF3
HO
N
H

6e


1.00
1.03
3.03
2.04
3.01
3.02
3.03
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


160.6738
157.8418
143.1494
138.5464
130.8146
127.6074
123.2064
122.9315
122.4626
119.9142
117.4232
116.2004
115.5286
113.4209
112.4228
61.2389
61.0422
60.8419
55.4982
OMe
CF3
HO
N
H
6e
f1 (ppm)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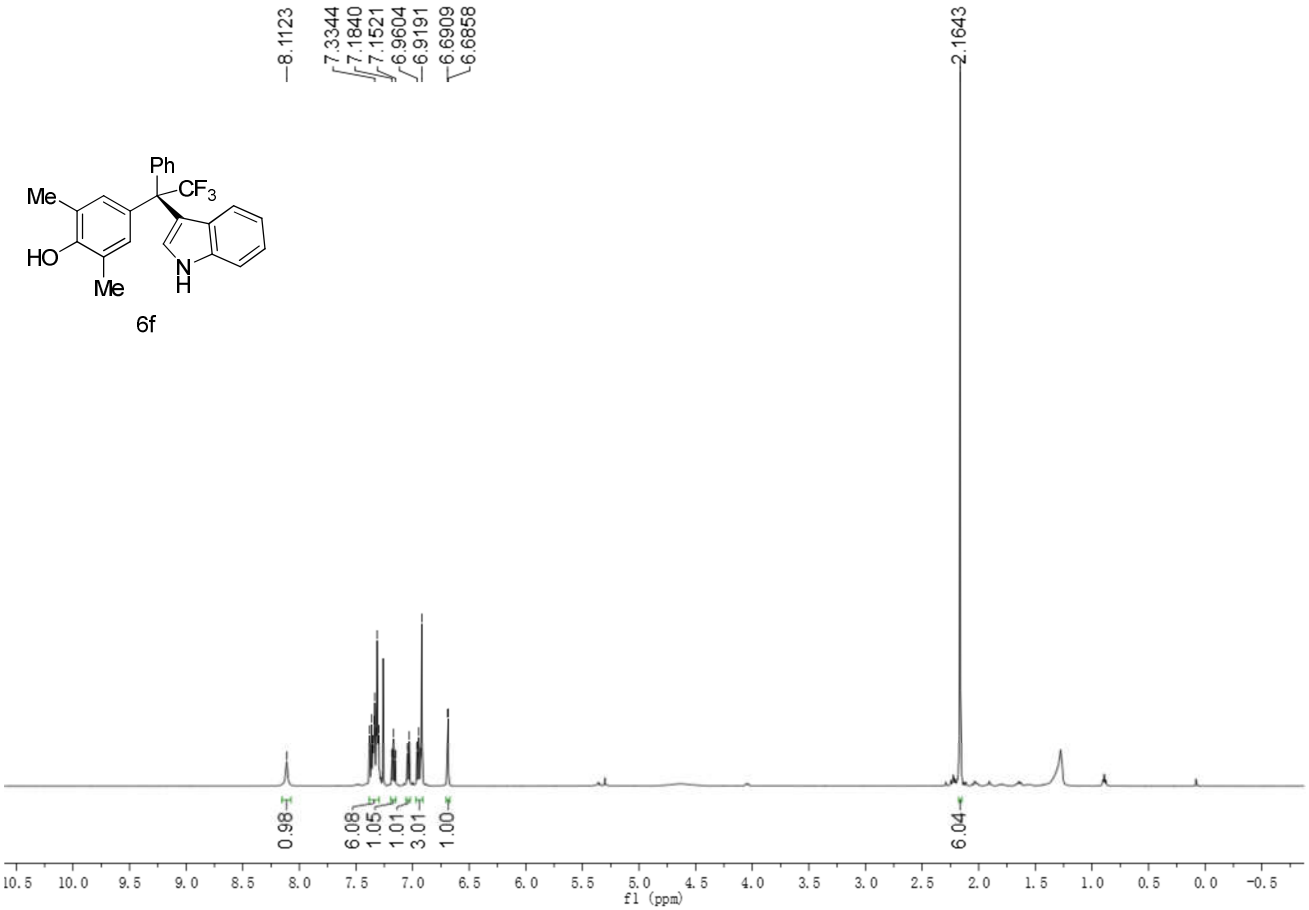
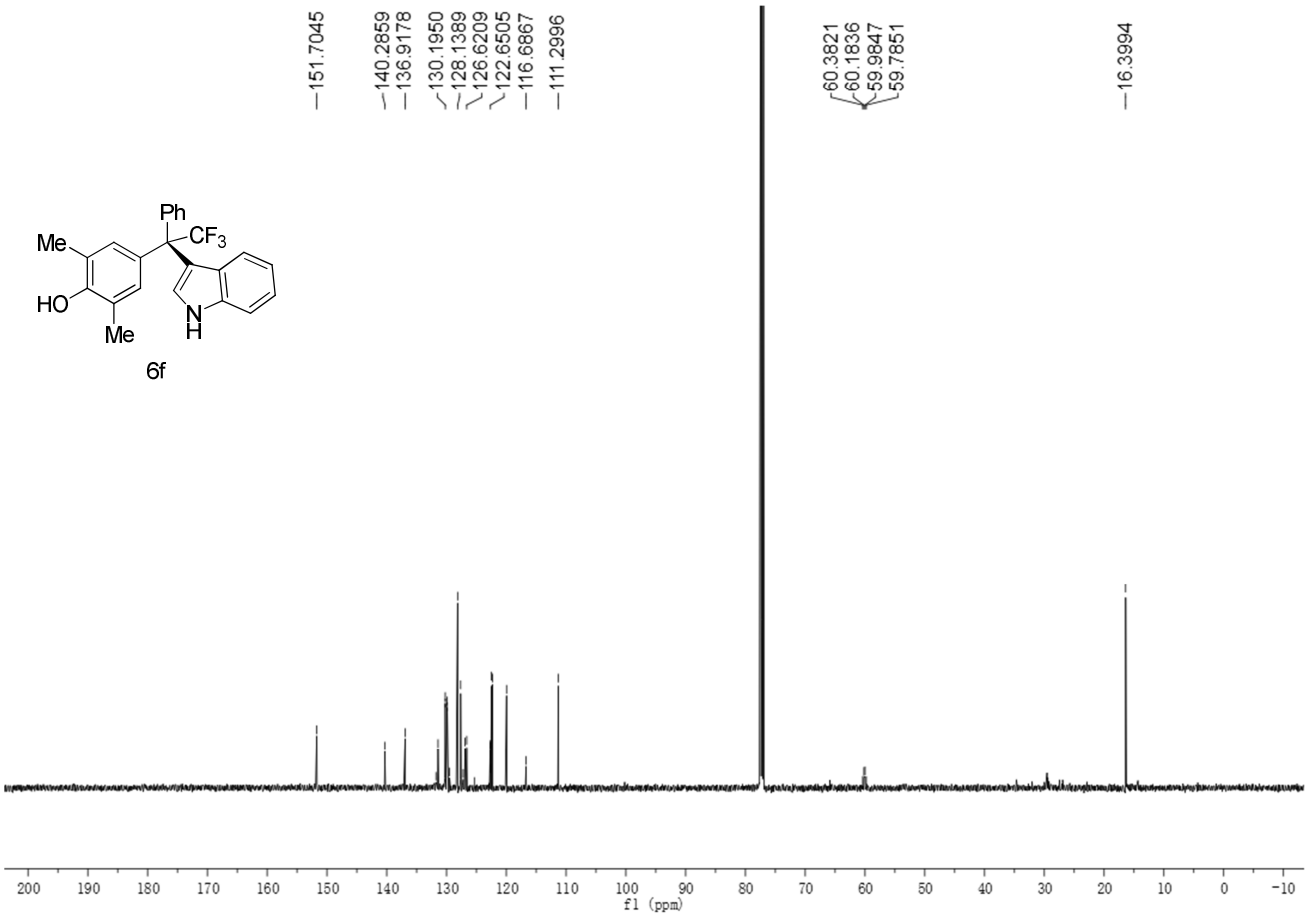
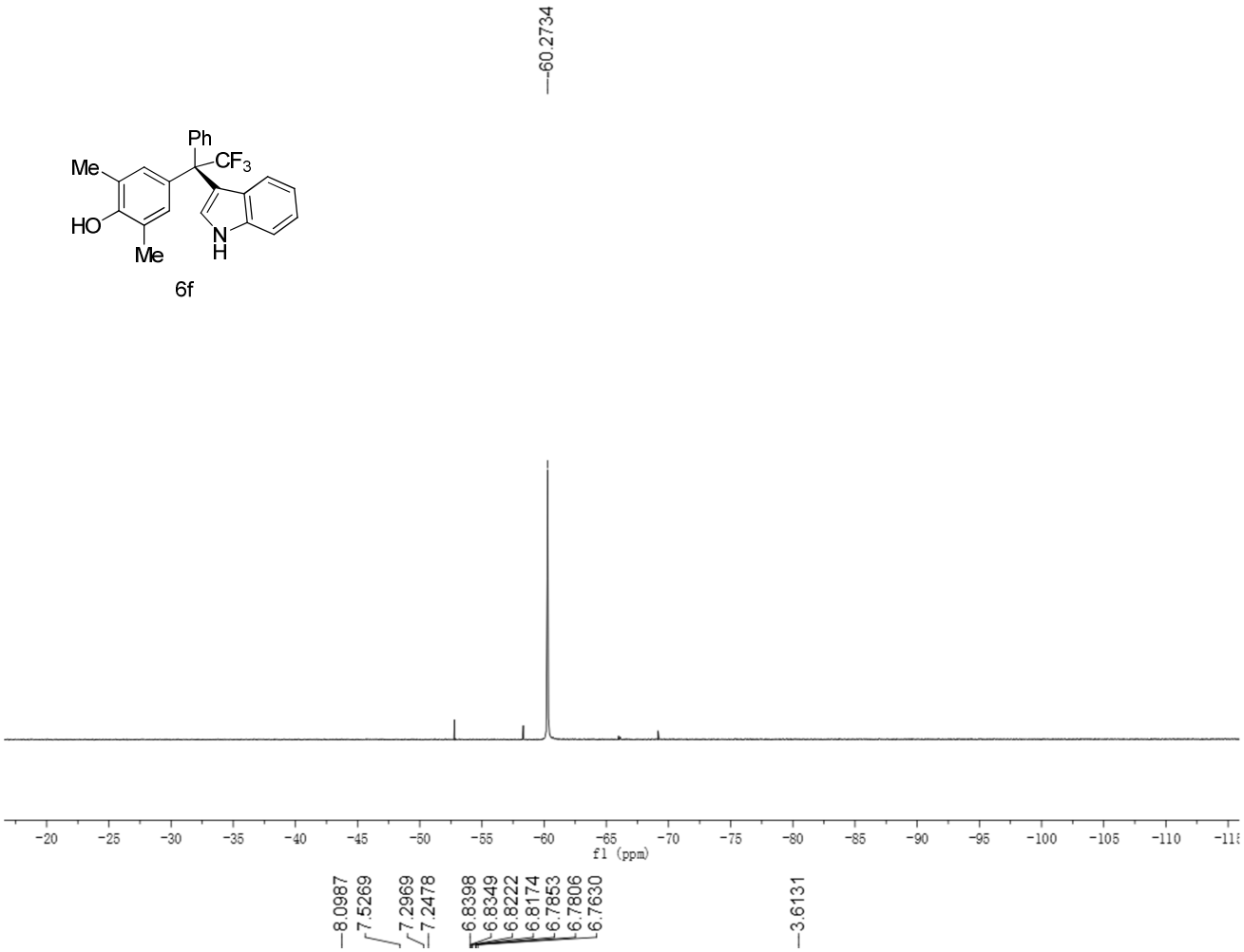
OMe
CF3
HO
N
H
6e
f1 (ppm)


8.1123
7.3344
7.1840
7.1521
6.9604
6.9191
6.6909
6.6858
2.1643
Ph
CF3
Me
HO
Me
N
H
6f
0.98
6.08
1.05
1.01
3.01
1.00
6.04
f1 (ppm)


151.7045
140.2859
136.9178
130.1950
128.1389
126.6209
122.6505
116.6867
111.2996
60.3821
60.1836
59.9847
59.7851
16.3994
Ph
CF3
Me
HO
Me
N
H
6f
f1 (ppm)

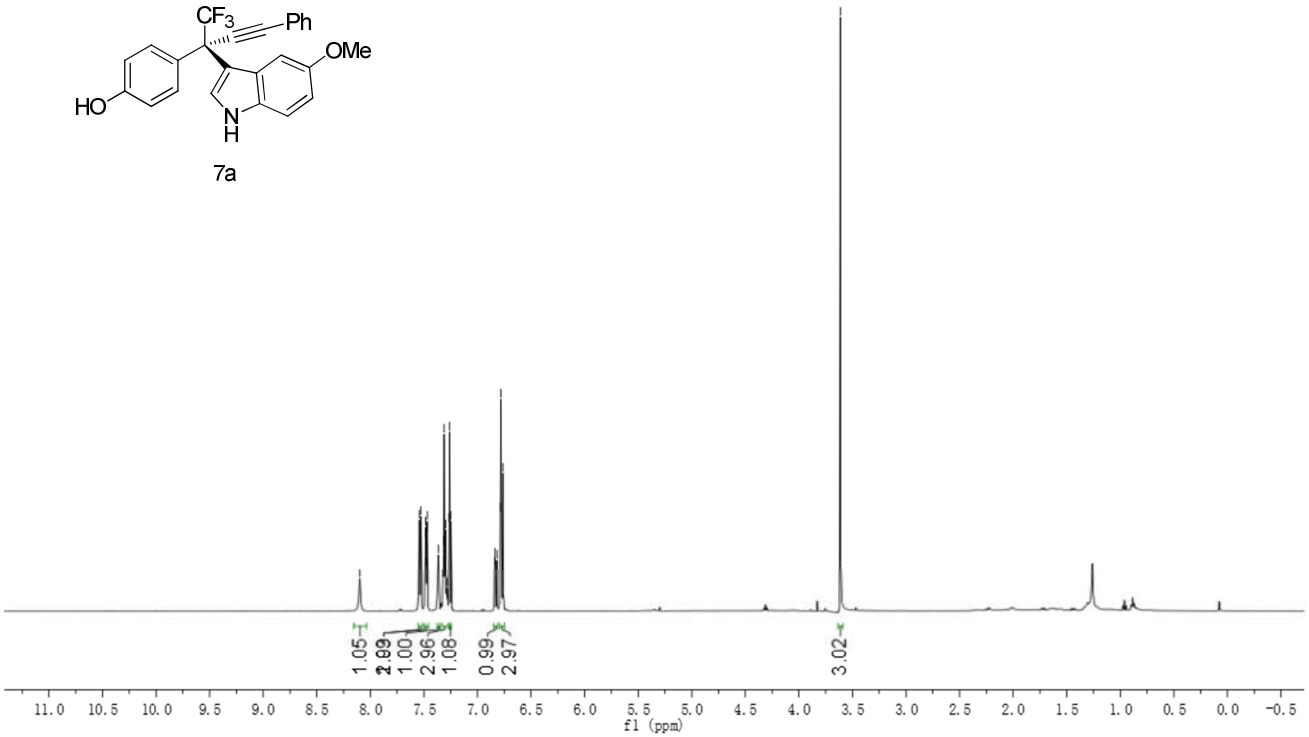
Ph
CF3
Me
HO
Me
N
H

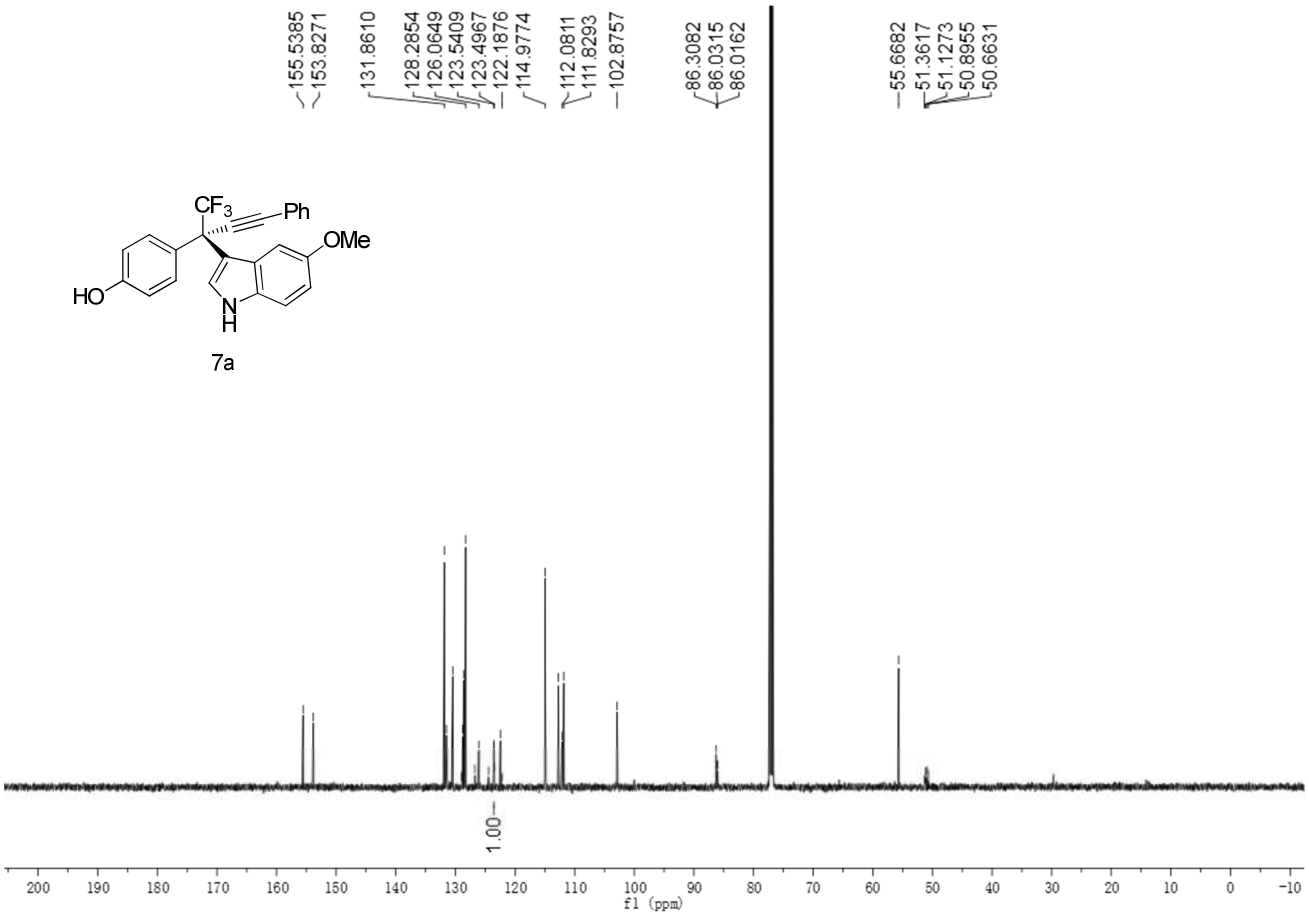
6f


-60.2734
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110
f1 (ppm)
8.0987
7.5269
7.2969
7.2478
6.8398
6.8349
6.8222
6.8174
6.7853
6.7806
6.7630
3.6131

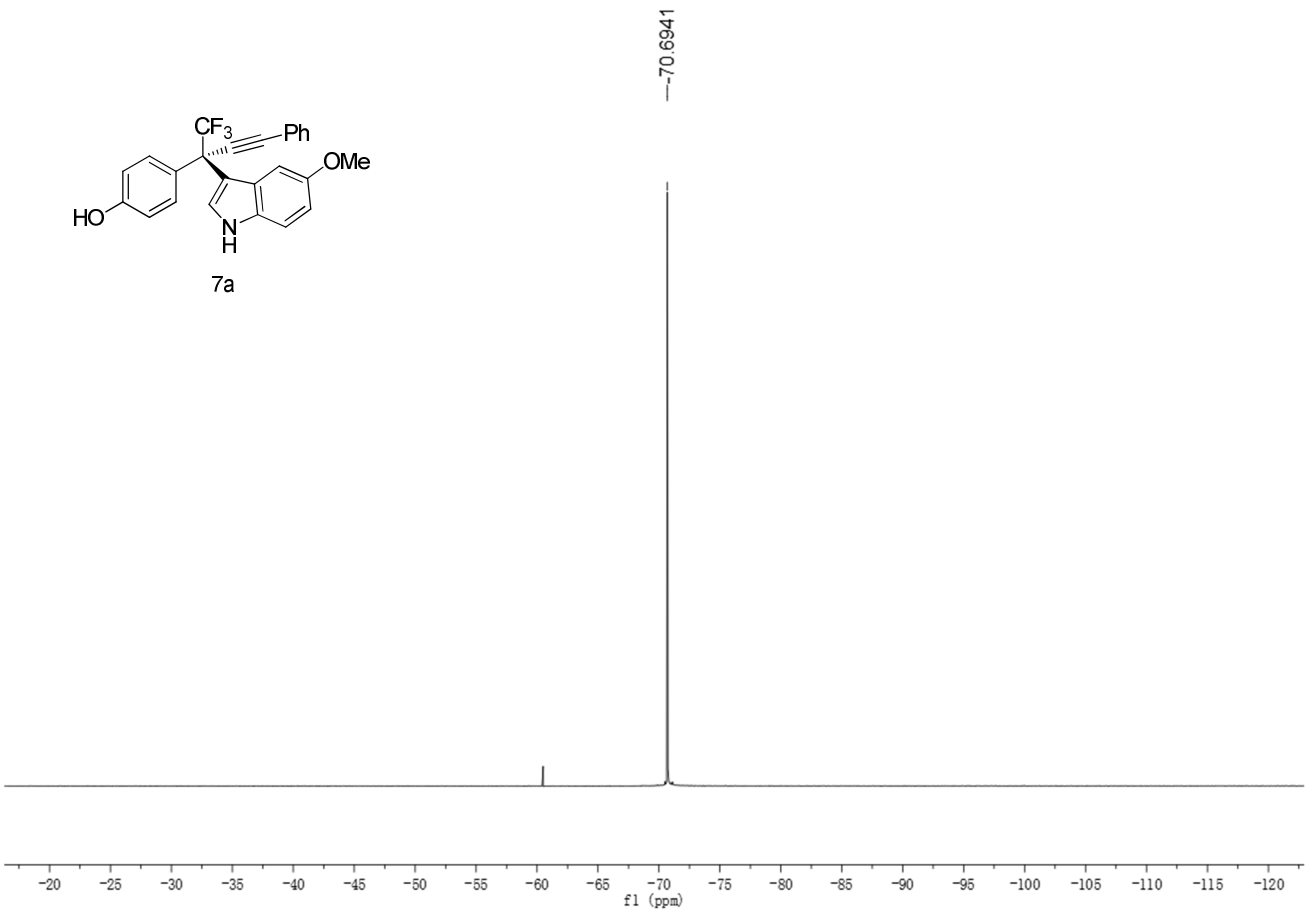
CF3
Ph
OMe
HO
N
H

7a

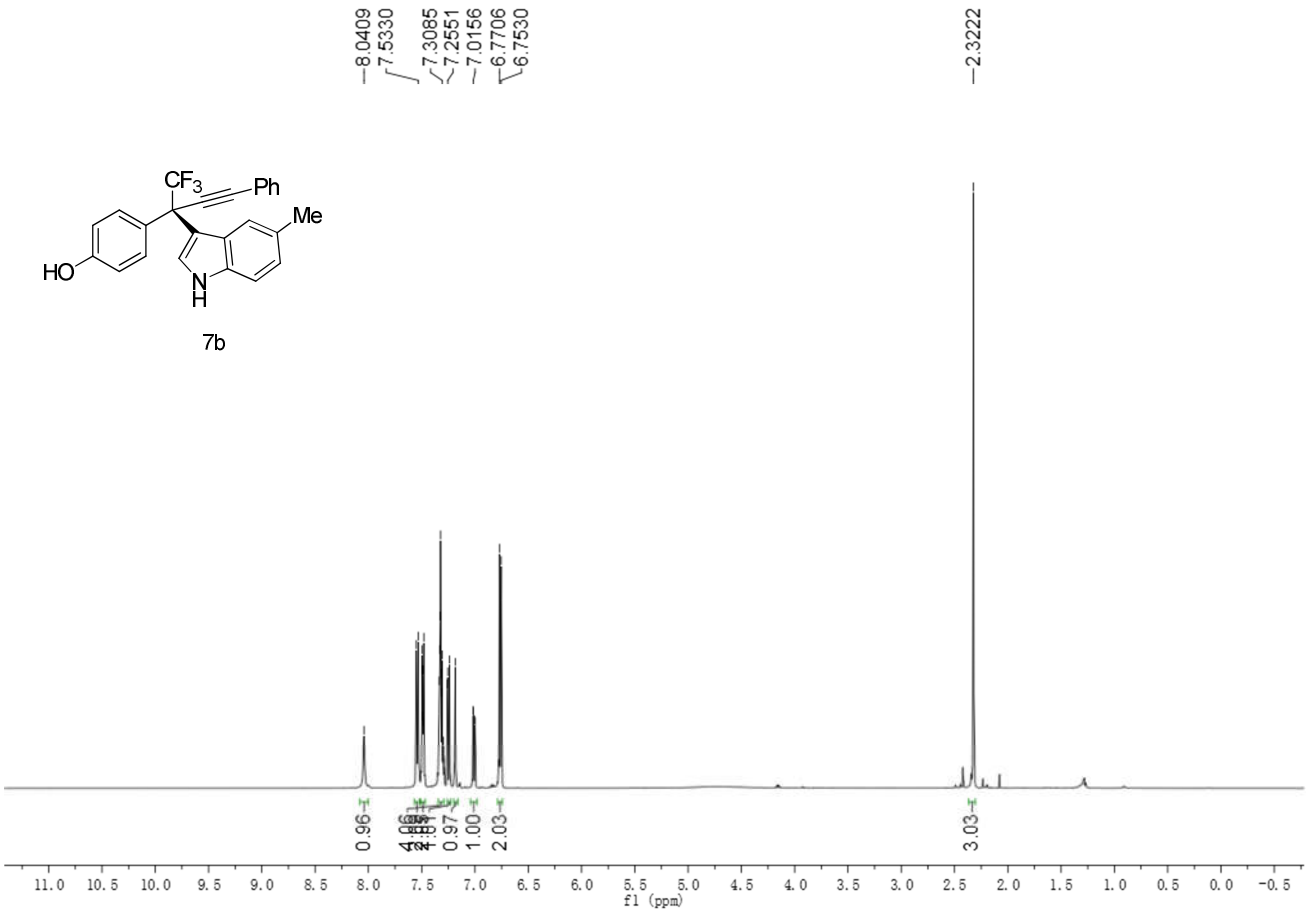

1.05
2.09
1.00
2.96
1.08
0.99
2.97
3.02
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


155.5385
153.8271
131.8610
128.2854
126.0649
123.5409
123.4967
122.1876
114.9774
112.0811
111.8293
102.8757
86.3082
86.0315
86.0162
55.6682
51.3617
51.1273
50.8955
50.6631
CF3
Ph
OMe
HO
N
H
1.00
f1 (ppm)

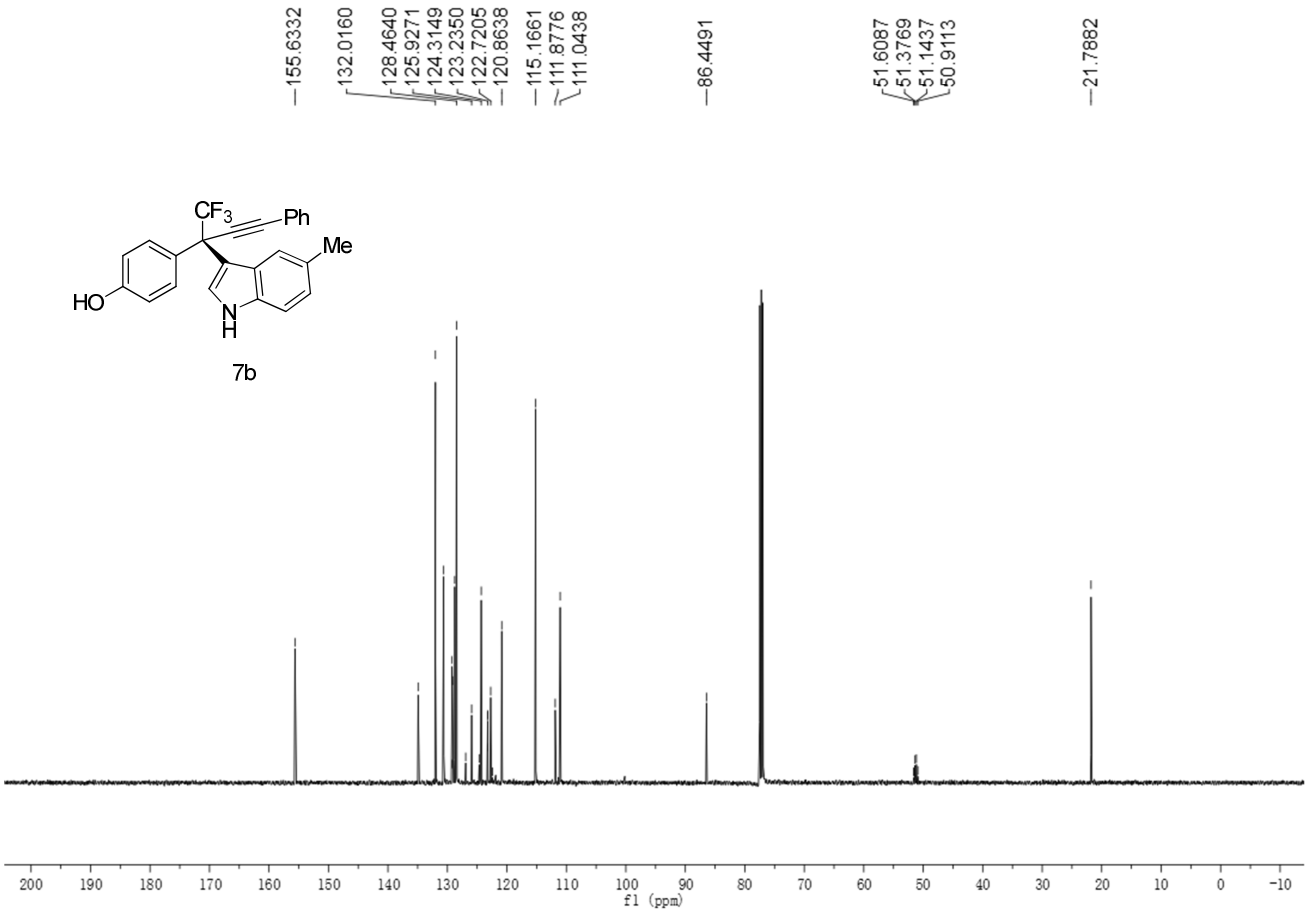
7a


-70.6941
CF3
Ph
OMe
HO
N
H
f1 (ppm)

7a


8.0409
7.5330
7.3085
7.2551
7.0156
6.7706
6.7530
2.3222
CF3
Ph
Me
HO
N
H
0.96
4.06
0.97
1.00
2.03
3.03
f1 (ppm)

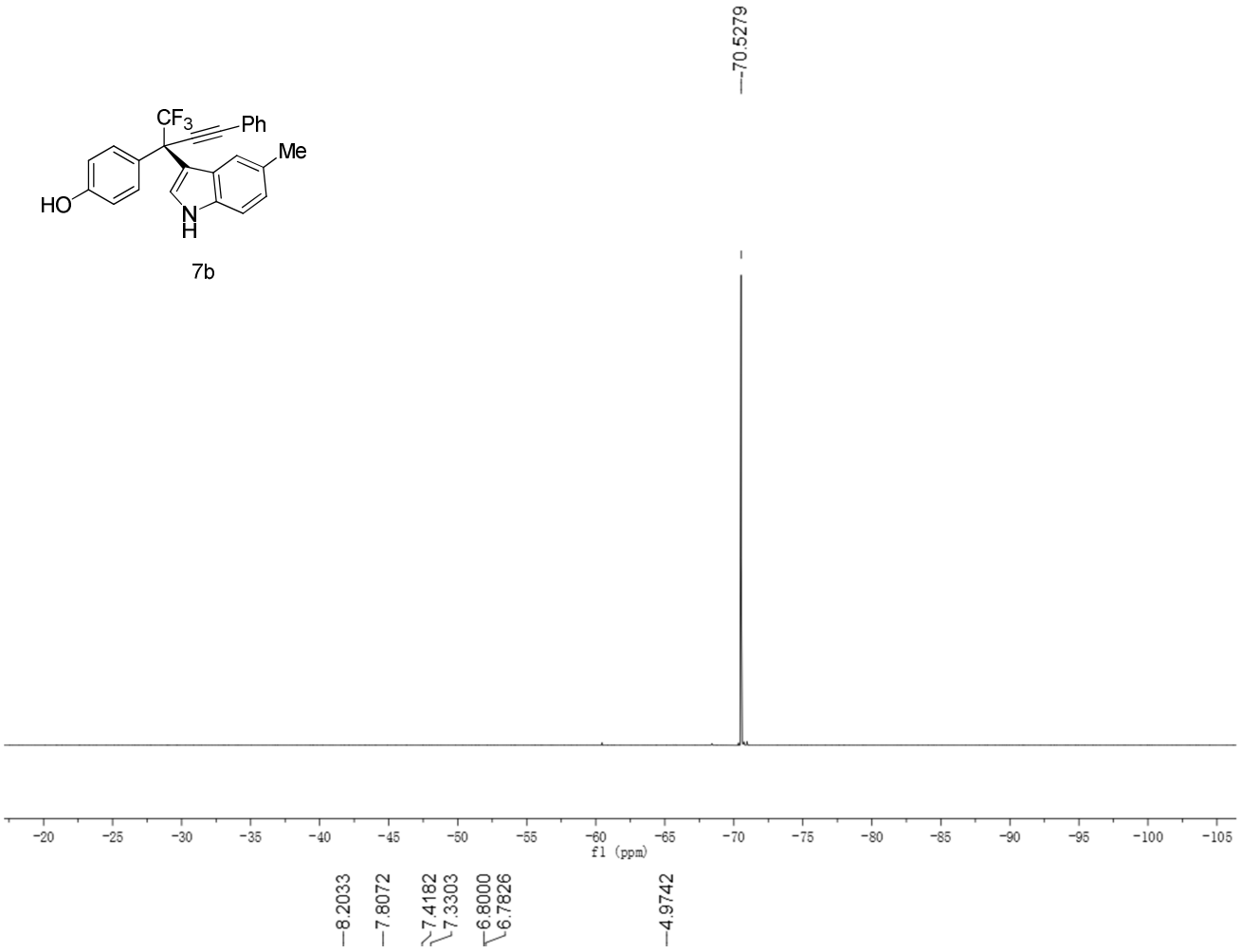
7b

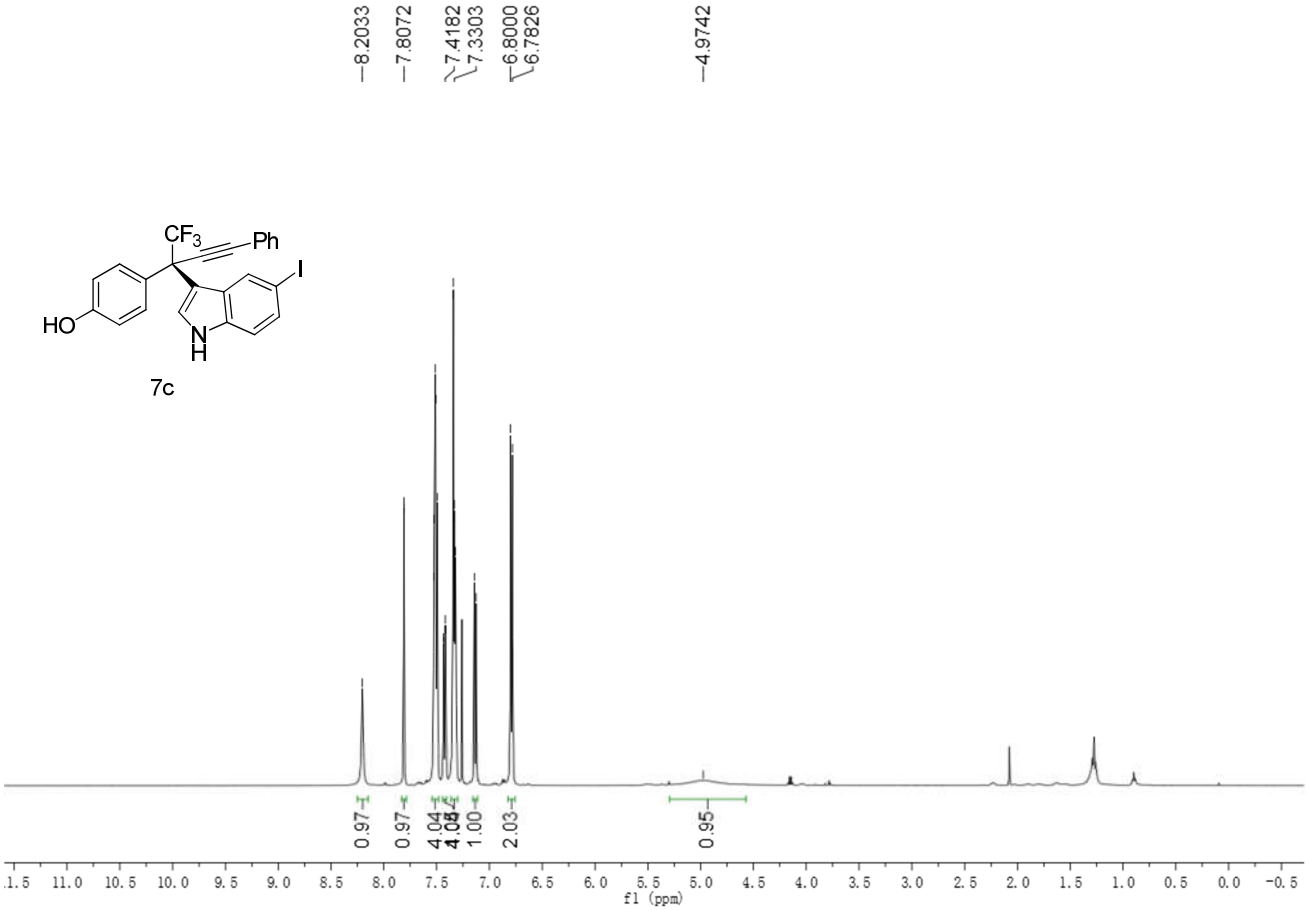

155.6332
132.0160
128.4640
125.9271
124.3149
123.2350
122.7205
120.8638
115.1661
111.8776
111.0438
86.4491
51.6087
51.3769
51.1437
50.9113
21.7882
CF3
Ph
Me
HO
N
H
f1 (ppm)

7b

CF3
Ph
Me
HO
N
H

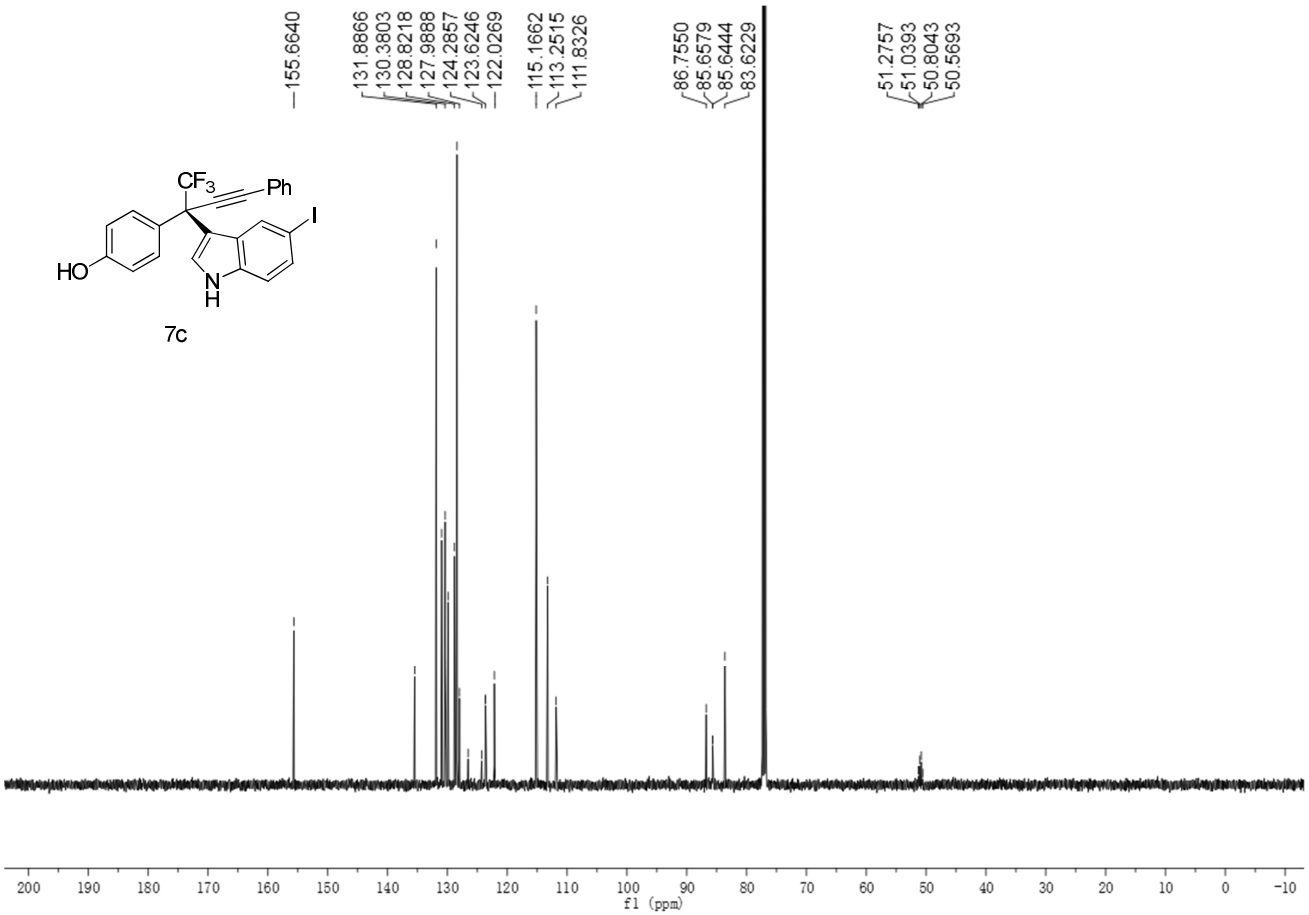
7b

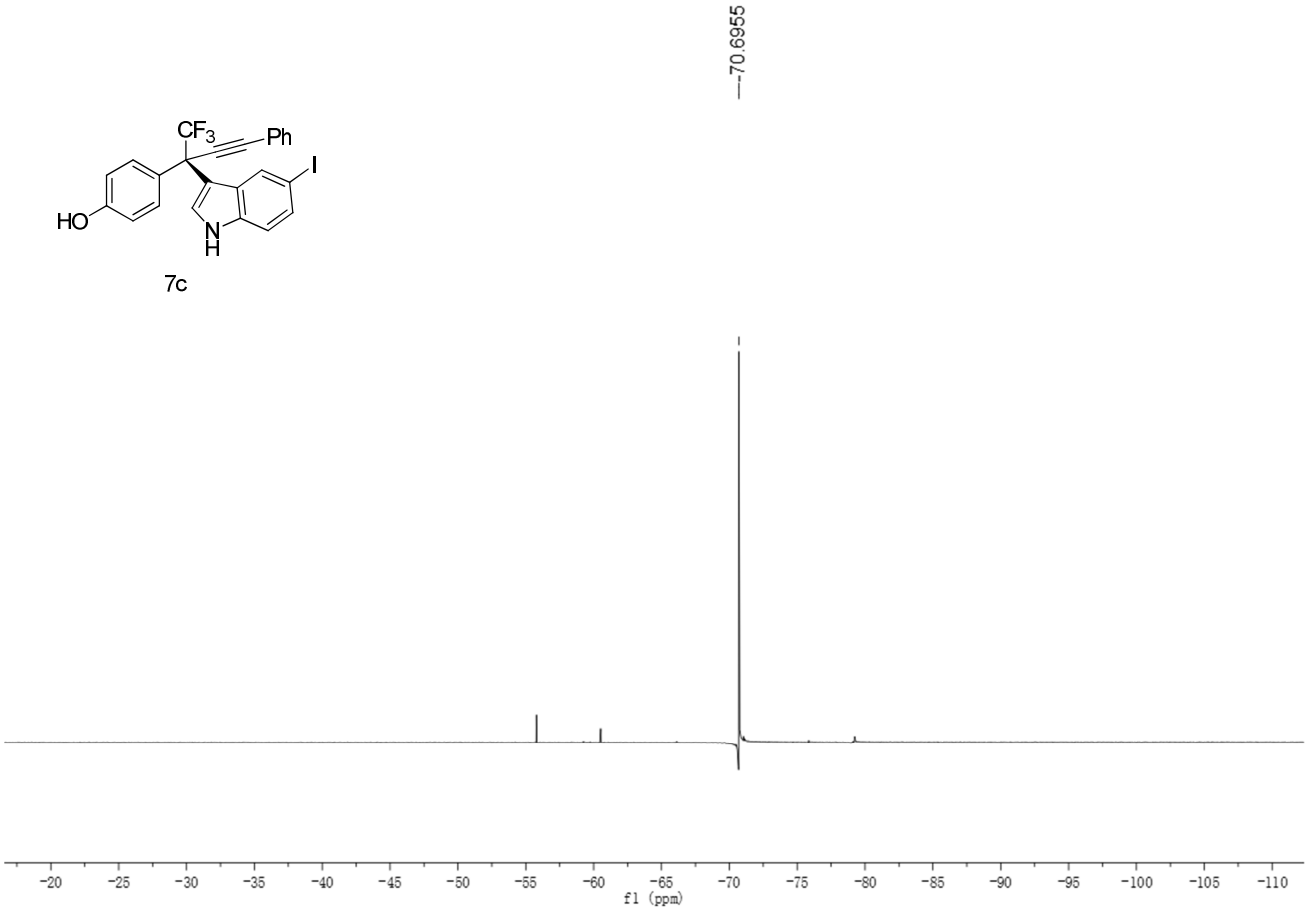

-70.5279
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-100
-105
f1 (ppm)

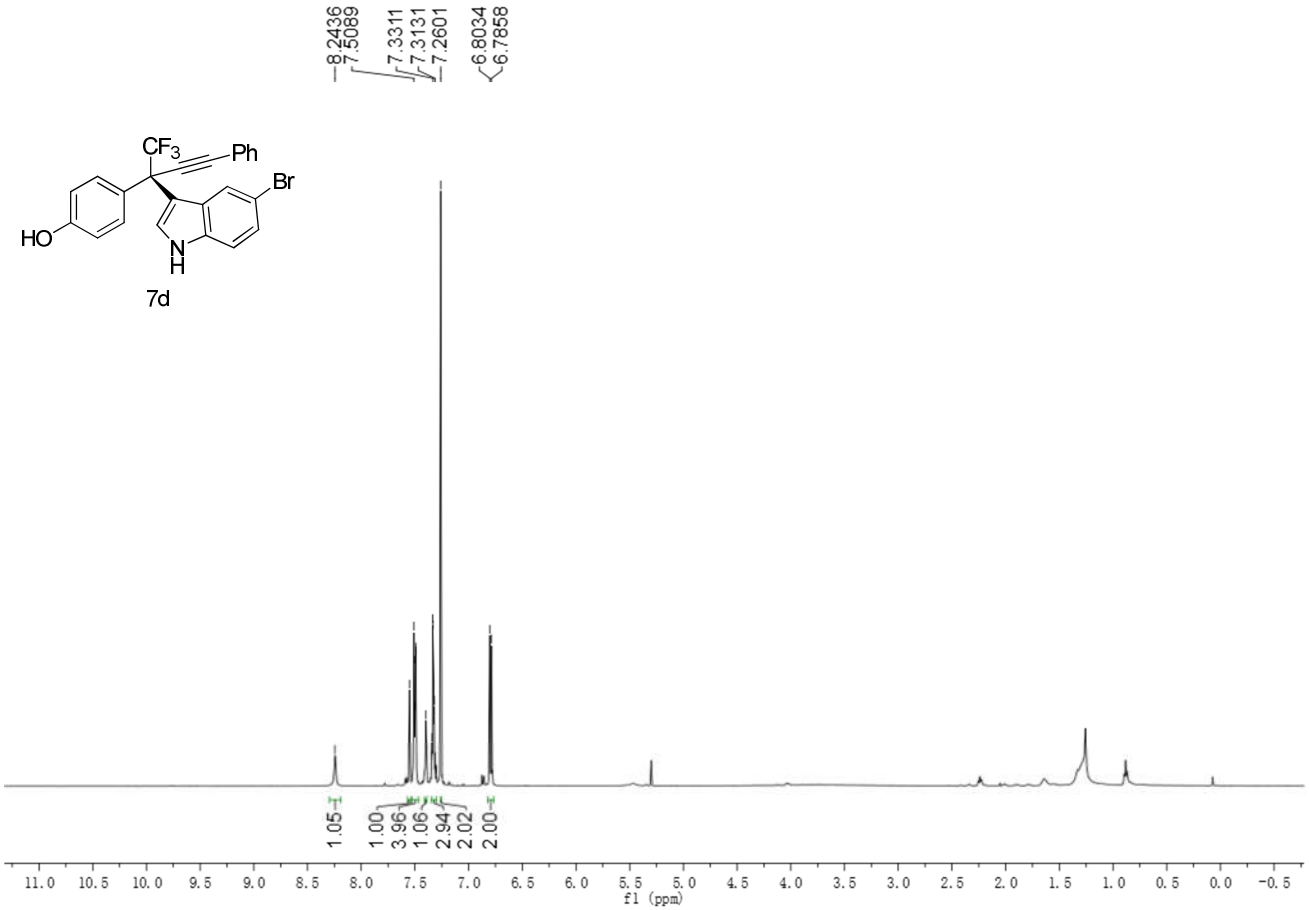

8.2033
7.8072
7.4182
7.3303
6.8000
6.7826
4.9742
0.97
0.97
4.04
1.00
2.03
0.95
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

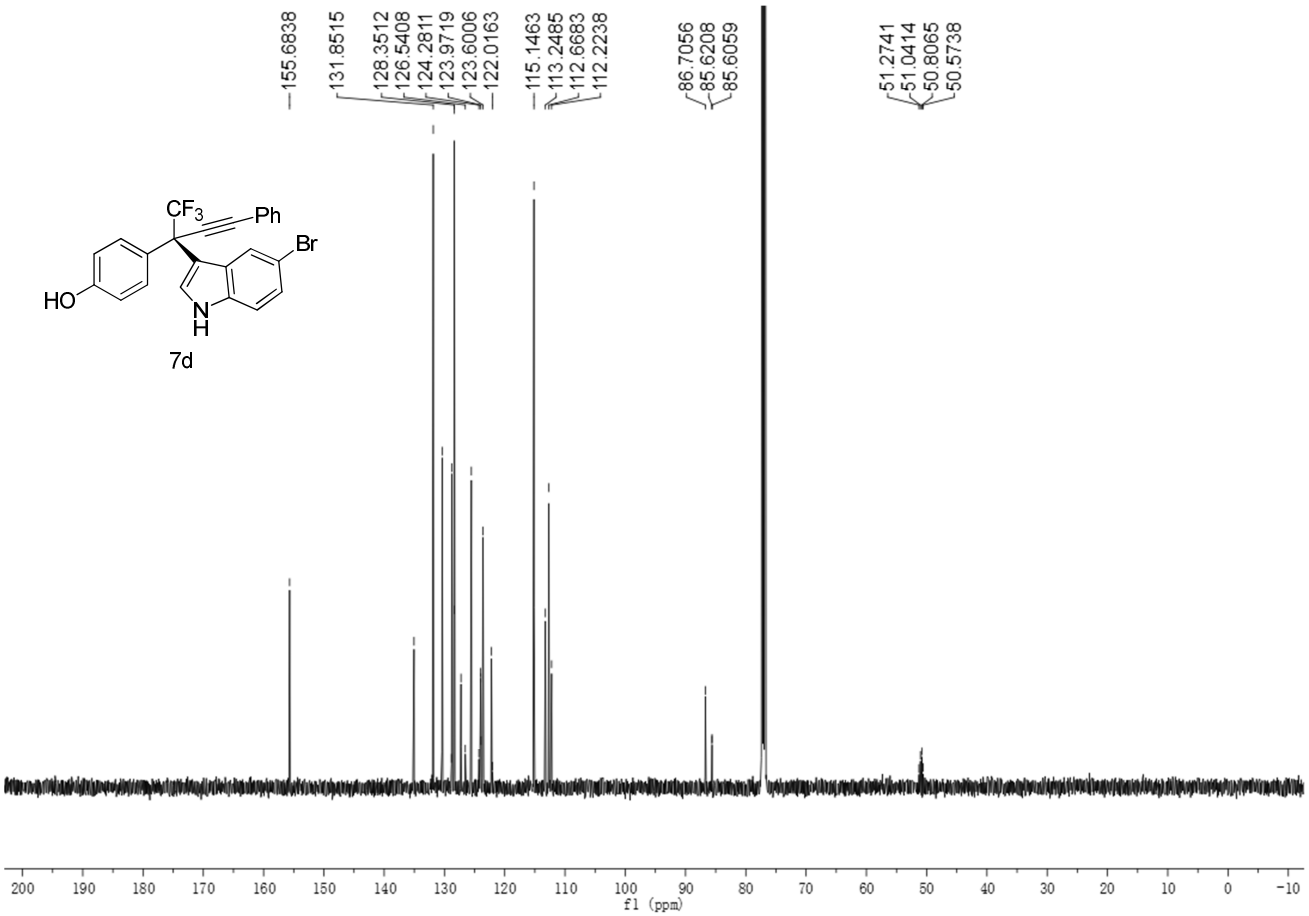
CF3
Ph
I
HO
N
H

7c


155.6640
131.8866
130.3803
128.8218
127.9888
124.2857
123.6246
122.0269
115.1662
113.2515
111.8326
86.7550
85.6579
85.6444
83.6229
51.2757
51.0393
50.8043
50.5693
CF3
Ph
I
HO
N
H
7c
f1 (ppm)

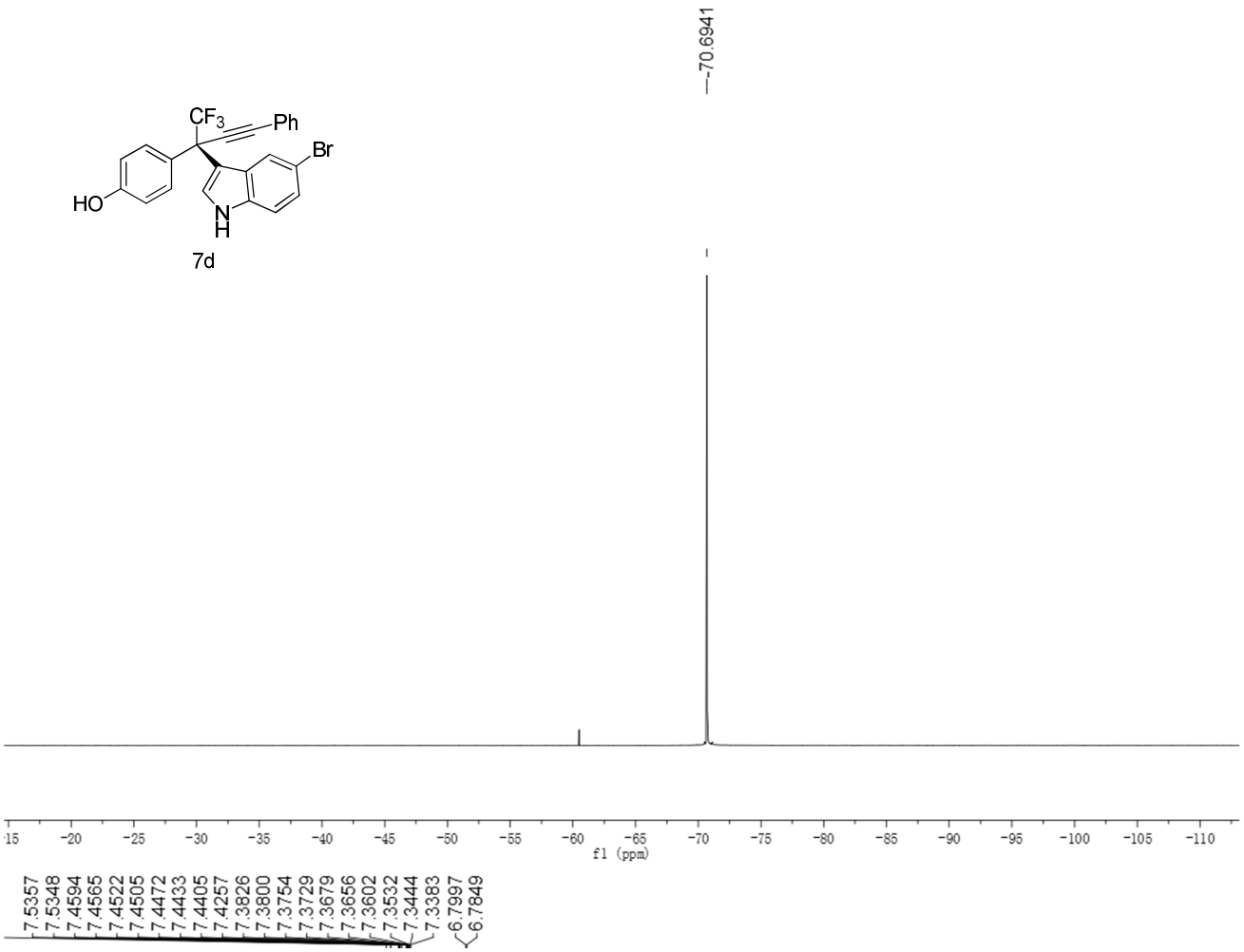

70.6955
CF3
Ph
I
HO
N
H
7c
f1 (ppm)


8.2436
7.5089
7.3311
7.3131
7.2601
6.8034
6.7858
CF3
Ph
Br
HO
N
H
7d
1.05
1.00
3.96
1.06
2.94
2.02
2.00
f1 (ppm)


155.6838
131.8515
128.3512
126.5408
124.2811
123.9719
123.6006
122.0163
115.1463
113.2485
112.6683
112.2238
86.7056
85.6208
85.6059
51.2741
51.0414
50.8065
50.5738
CF3
Ph
Br
HO
N
H
7d
f1 (ppm)

CF3
Ph
Br
HO
N
H

7d


-70.6941
f1 (ppm)

7.5357
7.5348
7.4594
7.4565
7.4522
7.4505
7.4472
7.4433
7.4405
7.4257
7.3826
7.3800
7.3754
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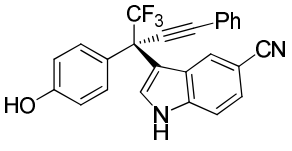
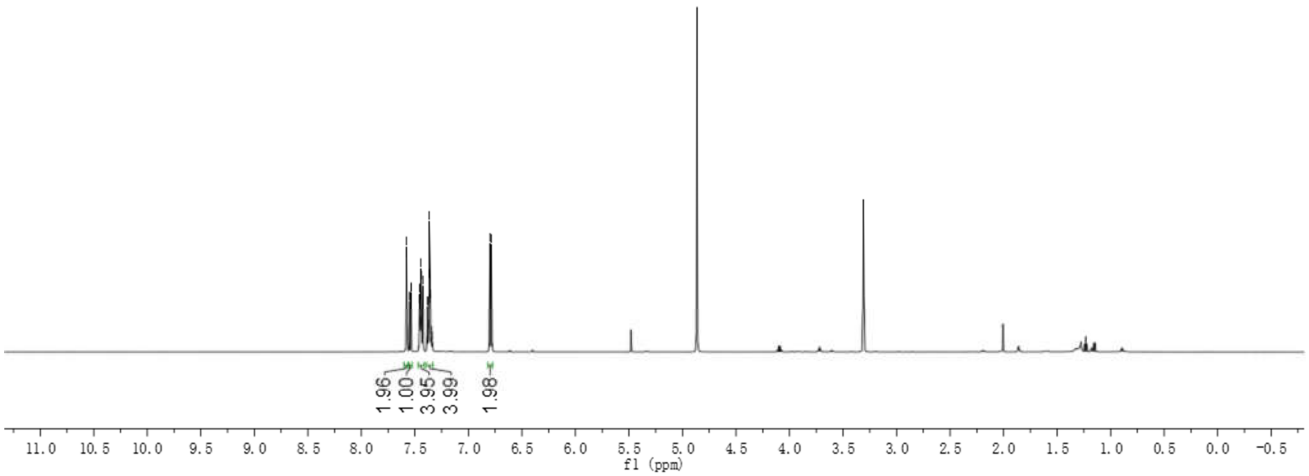
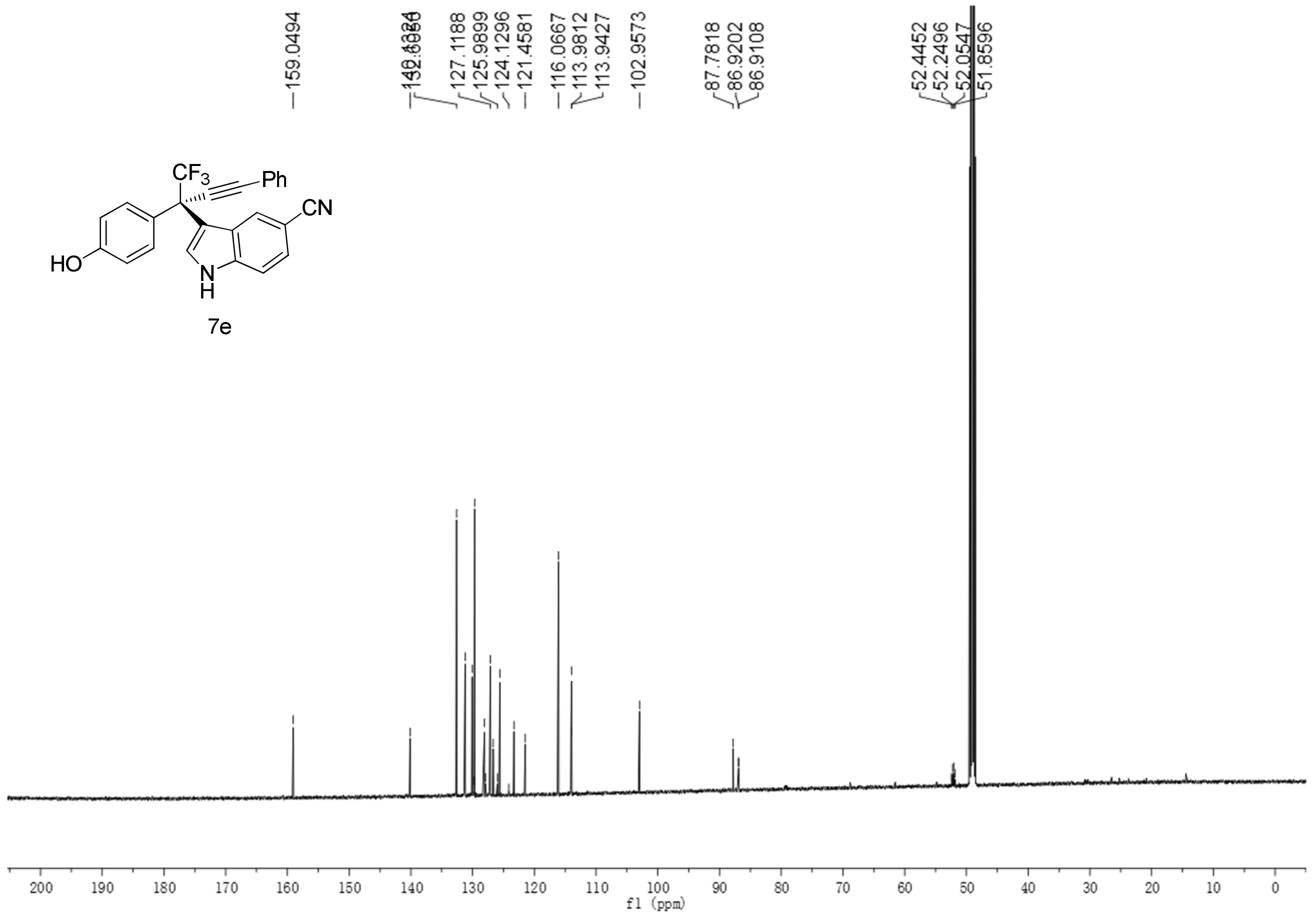
7.3679
7.3656
7.3602
7.3532
7.3444
7.3383
6.7997
6.7849


CF3
Ph
CN
HO
N
H

7e


1.96
1.00
3.95
3.99
1.98
f1 (ppm)



159.0494
127.1188
125.9899
124.1296
121.4581
116.0667
113.9812
113.9427
102.9573
87.7818
86.9202
86.9108
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52.2496
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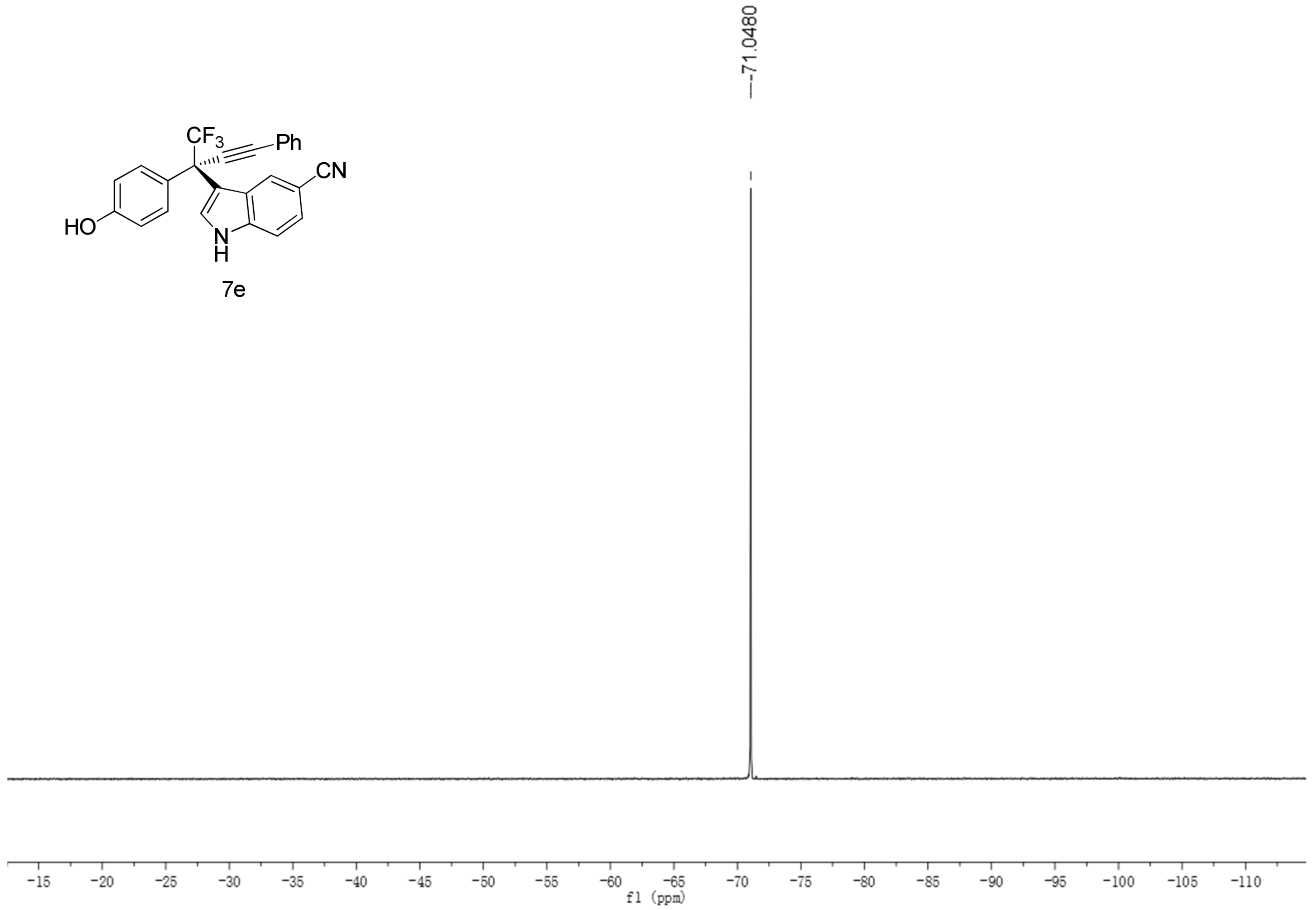
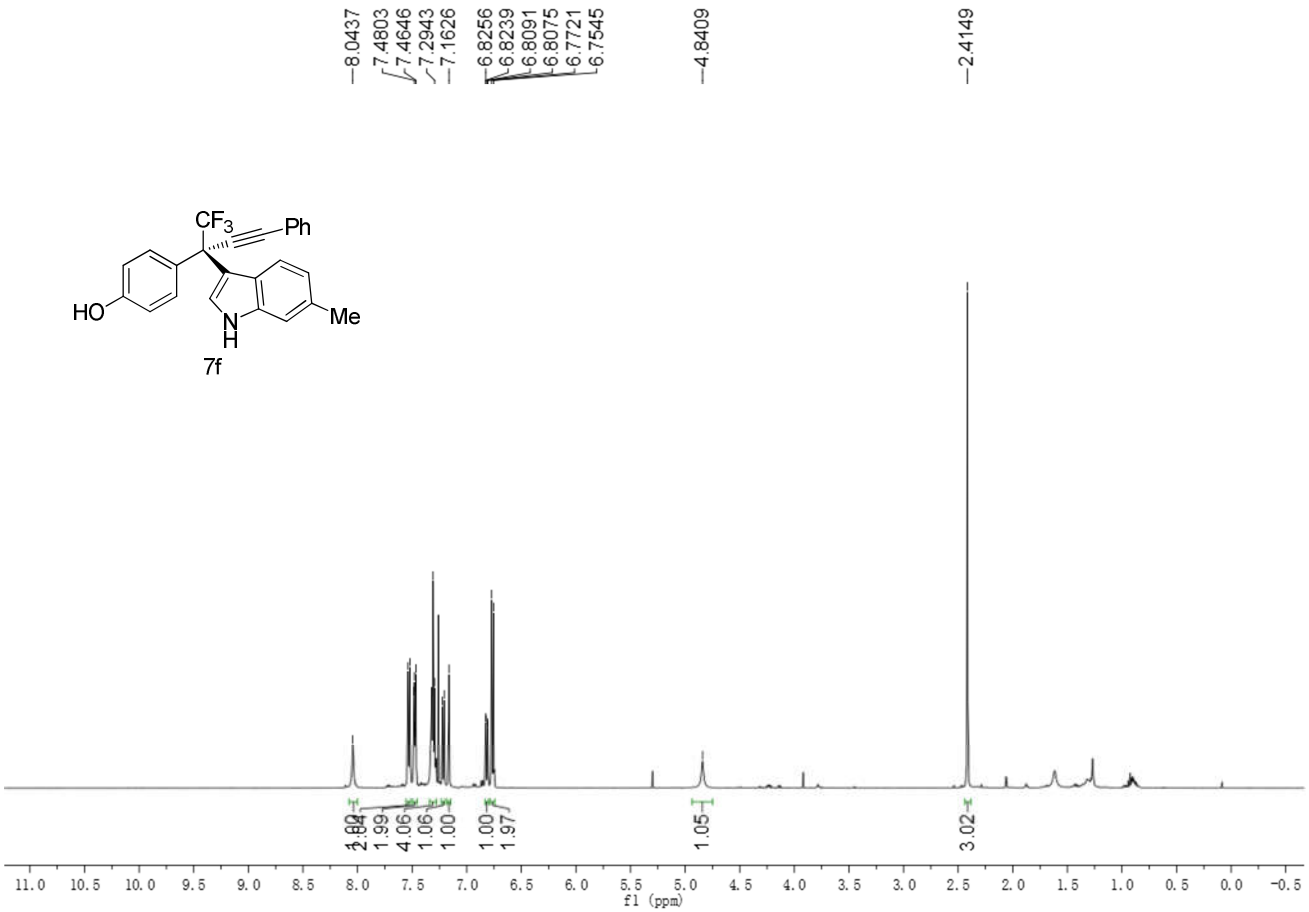
51.8596
CF3
Ph
CN
HO
H
N
7e
f1 (ppm)



-71.0480
CF3
Ph
CN
HO
H
N
7e
f1 (ppm)


8.0437
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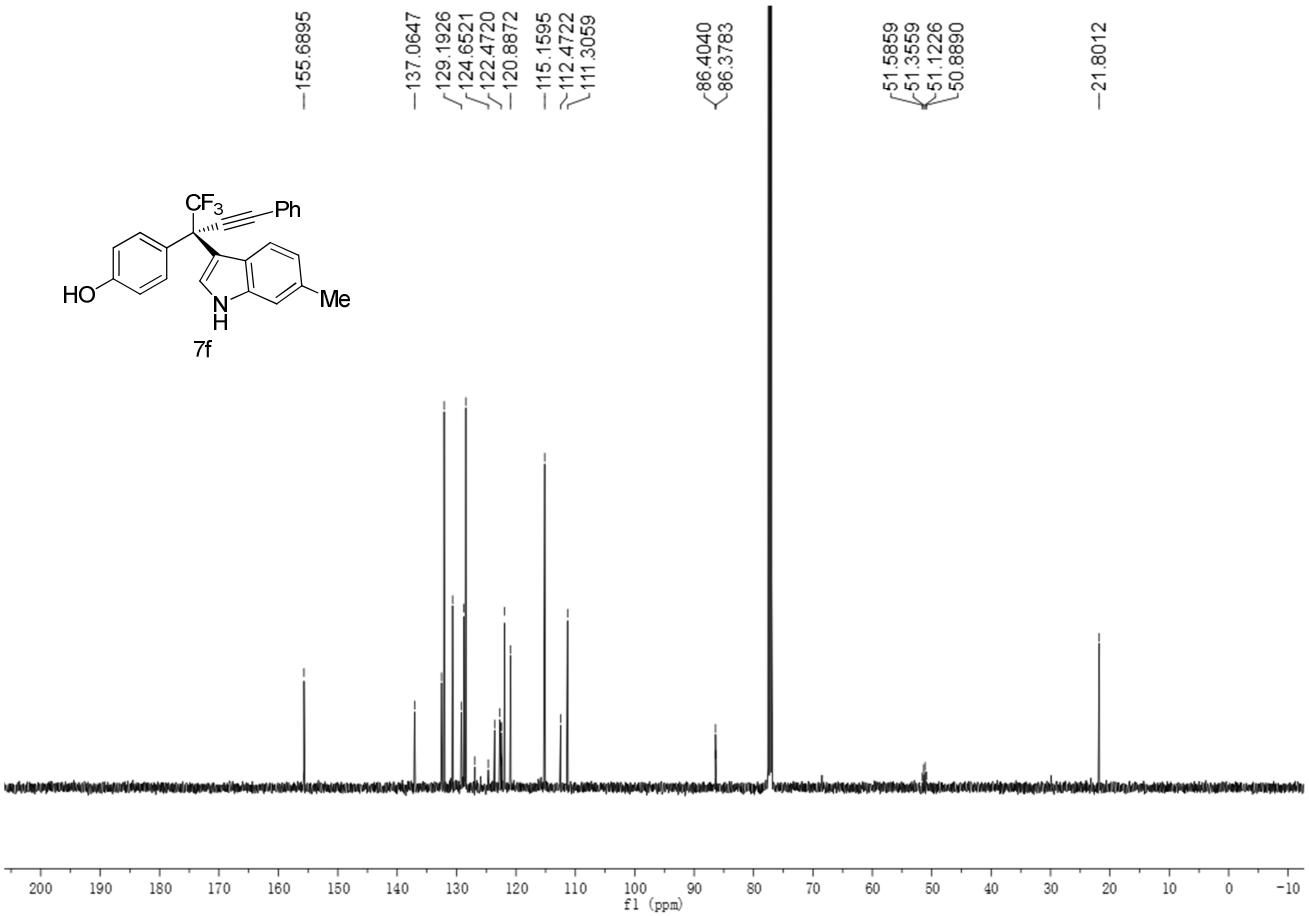
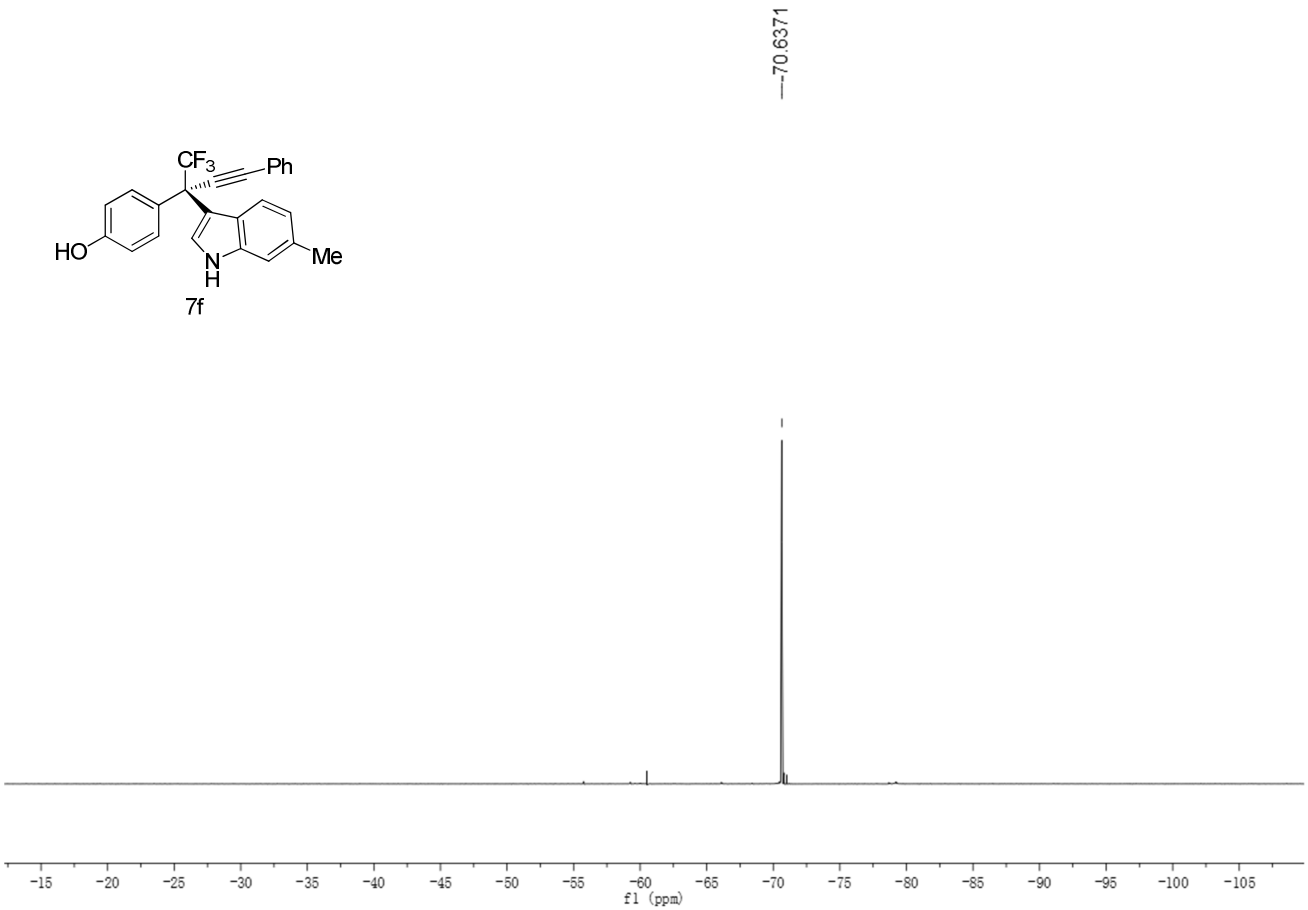
7.4646
7.2943
7.1626
6.8256
6.8239
6.8091
6.8075
6.7721
6.7545
4.8409
2.4149
CF3
Ph
HO
Me
N
H
7f
1.00
2.04
1.99
4.06
1.06
1.00
1.00
1.97
1.05
3.02
f1 (ppm)


155.6895
137.0647
129.1926
124.6521
122.4720
120.8872
115.1595
112.4722
111.3059
86.4040
86.3783
51.5859
51.3559
51.1226
50.8890
21.8012
CF3
Ph
HO
Me
N
H
7f
f1 (ppm)

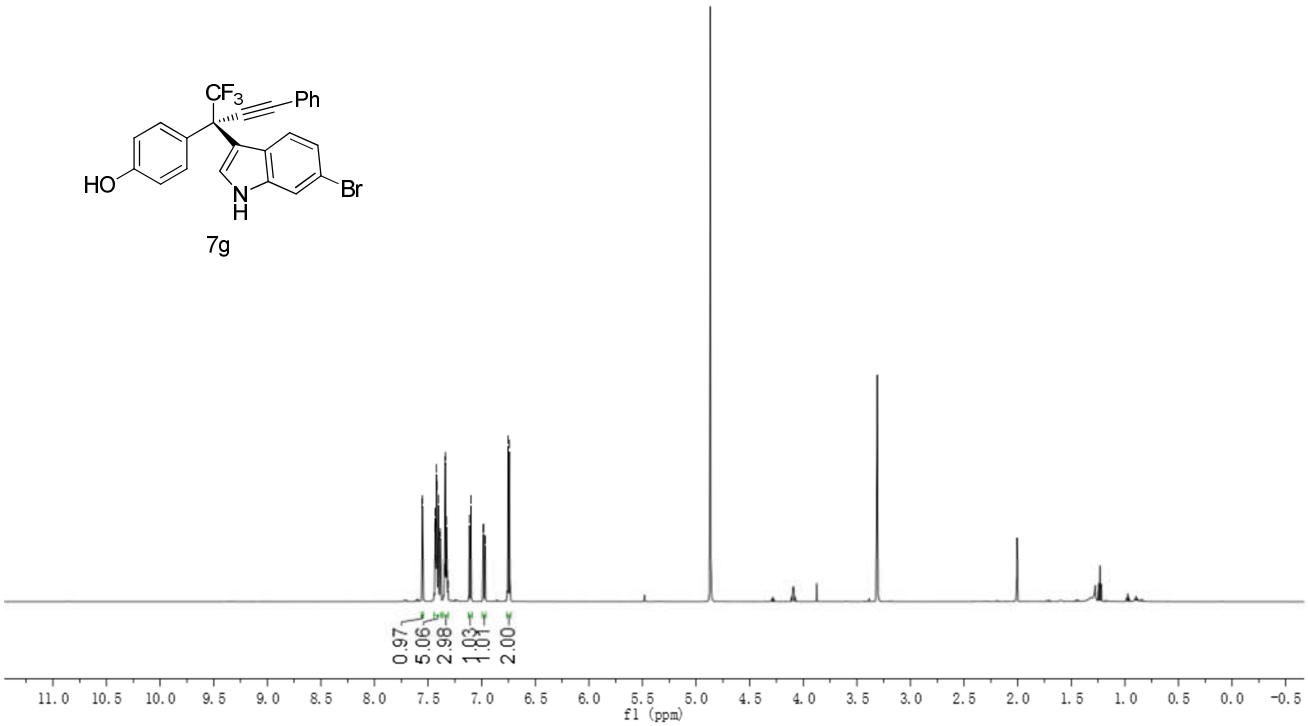
CF3
Ph
HO
Me
N
H

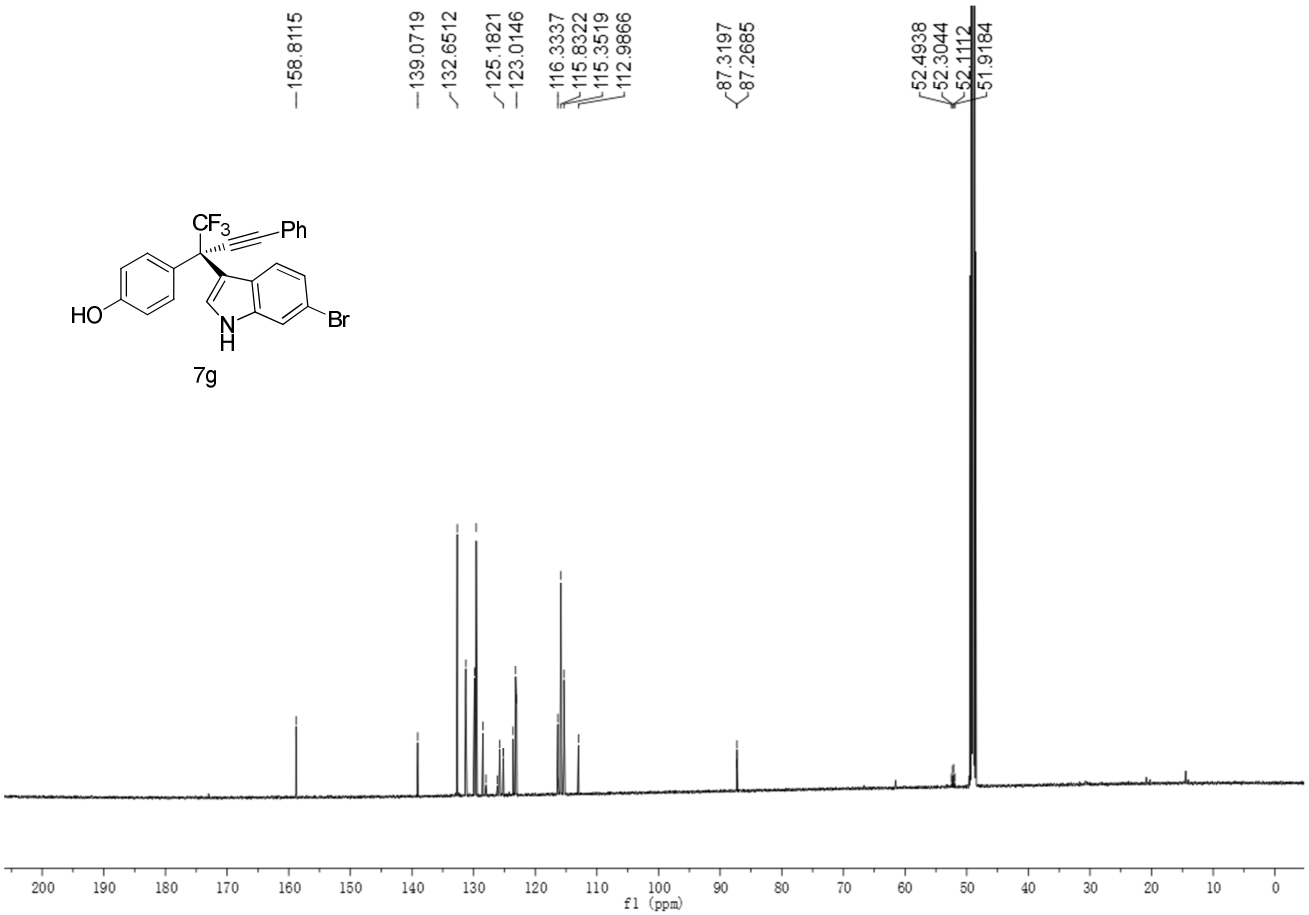
7f

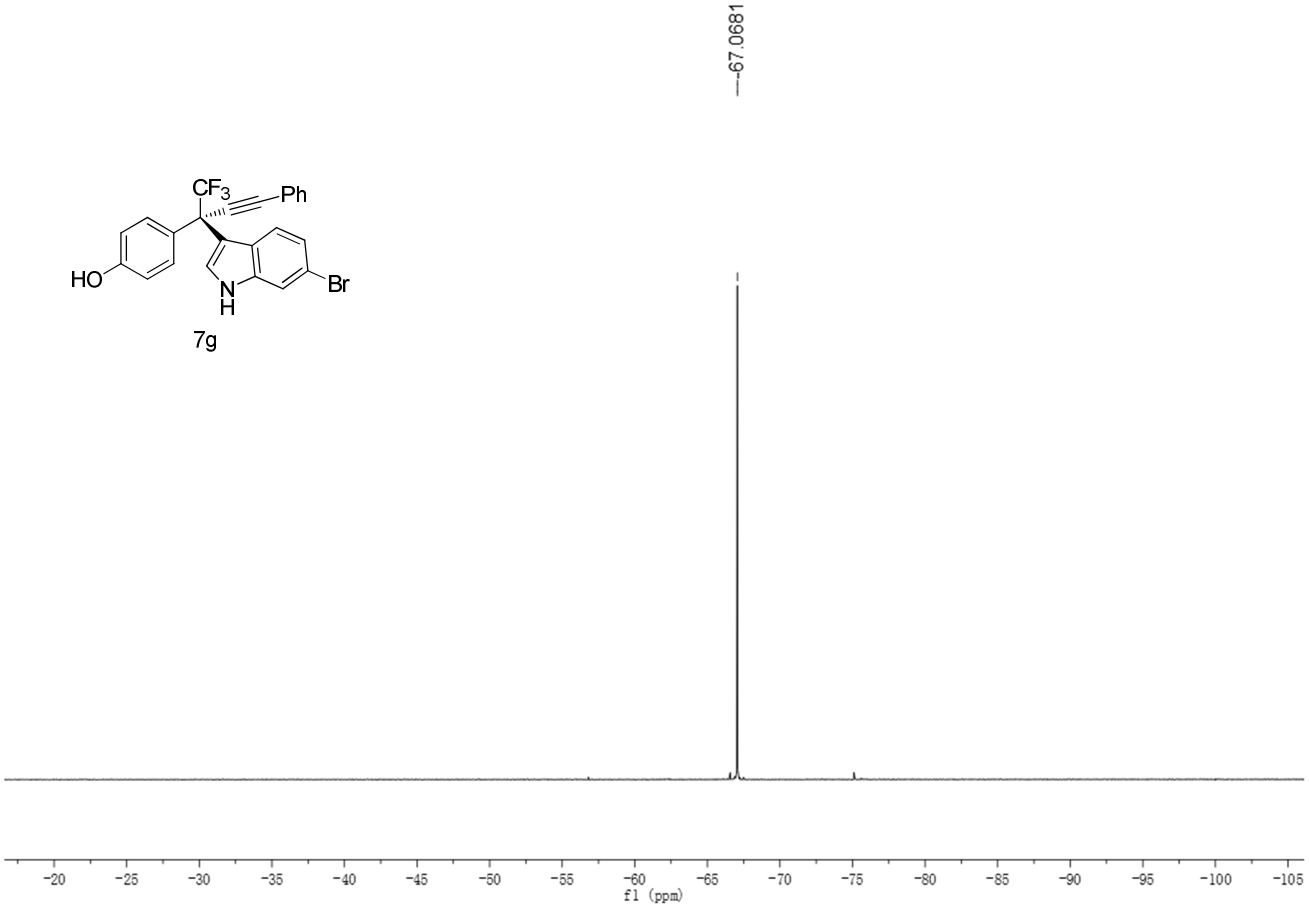

-70.6371
-15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105
f1 (ppm)
7.4342
7.4308
7.4253
7.4210
7.4187
7.4041
7.3878
7.3854
7.3468
7.3450
7.3406
7.3387
7.3284
7.3197
7.3133
7.1151
7.1007
6.9853
6.9823
6.9709
6.9680
6.7546
6.7398

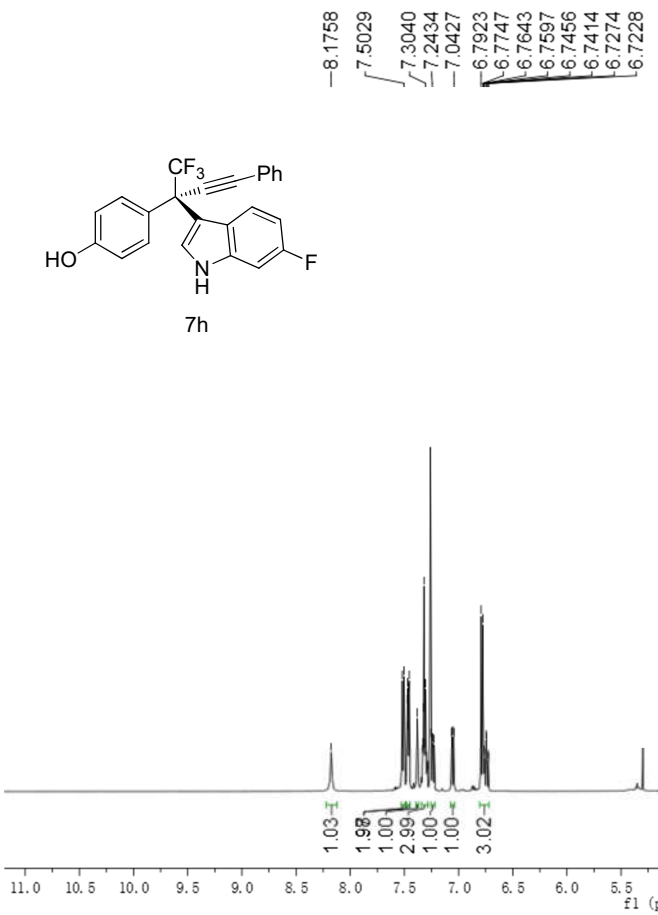
CF3
Ph
HO
Br
N
H

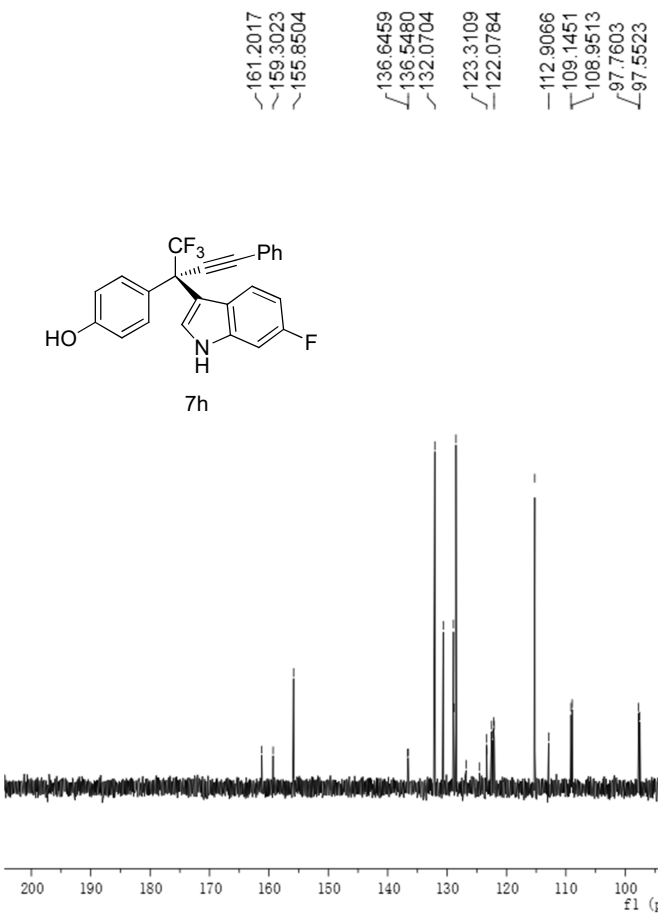
7g

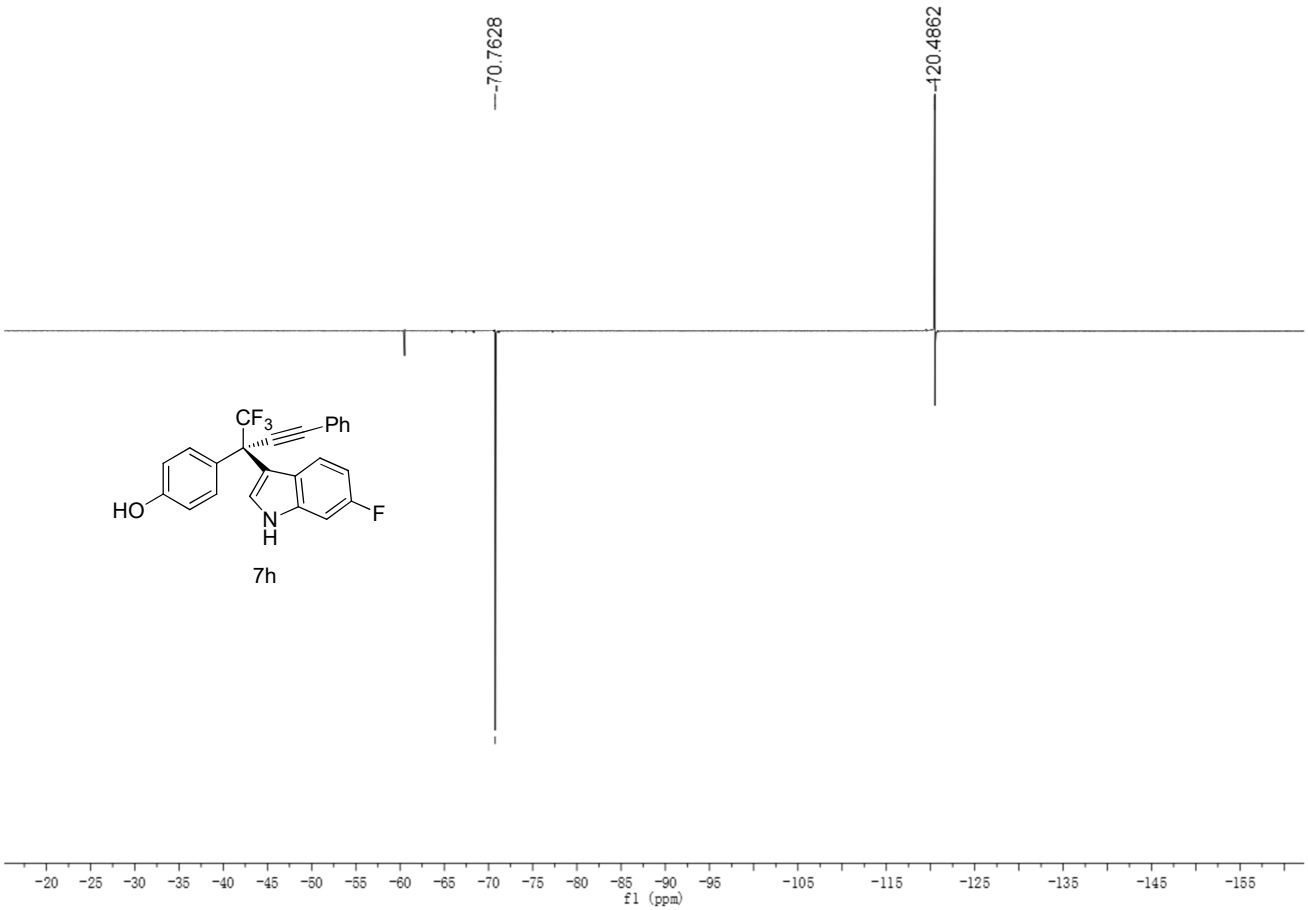

0.97
5.06
2.98
1.03
1.01
2.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


158.8115
139.0719
132.6512
125.1821
123.0146
116.3337
115.8322
115.3519
112.9866
87.3197
87.2685
52.4938
52.3044
52.1112
51.9184
CF3
Ph
HO
Br
N
H
7g
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

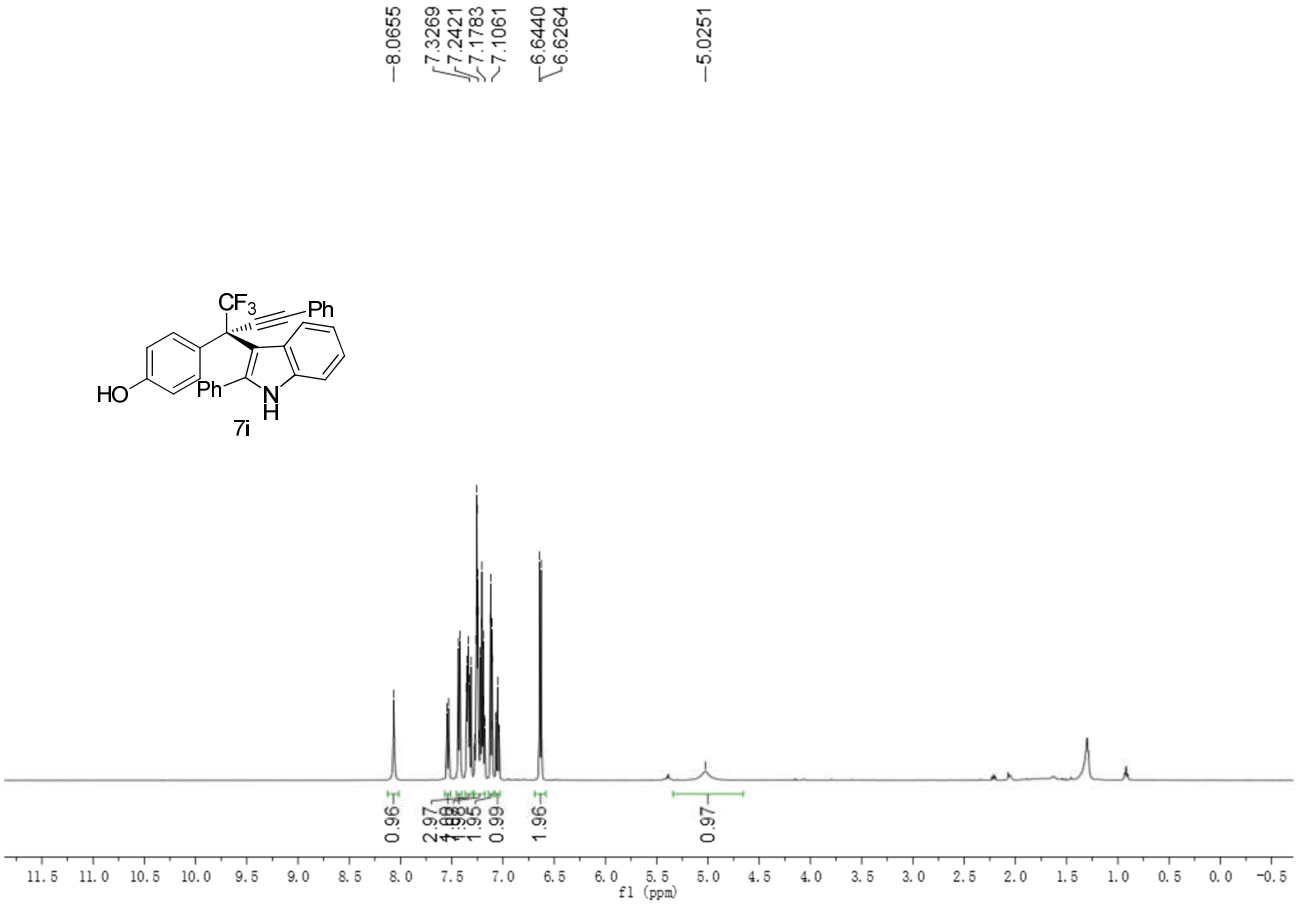

-67.0681
CF3
Ph
HO
Br
N
H
7g
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105
f1 (ppm)


8.1758
7.5029
7.3040
7.2434
7.0427
6.7923
6.7747
6.7643
6.7597
6.7456
6.7414
6.7274
6.7228
CF3
Ph
HO
F
N
H
7h
1.03
1.98
1.00
2.99
1.00
1.00
3.02
f1 (ppm)

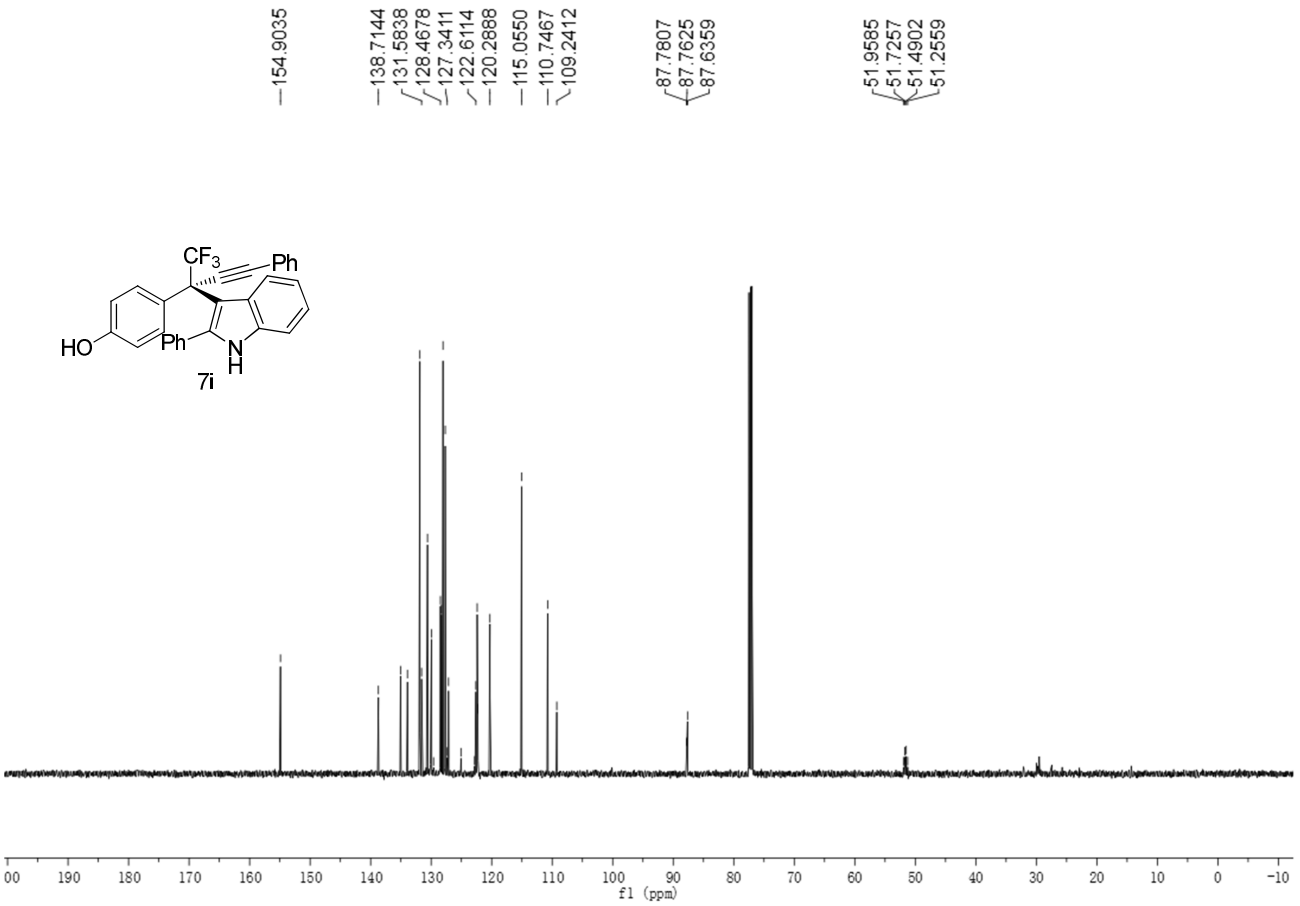

161.2017
159.3023
155.8504
136.6459
136.5480
132.0704
123.3109
122.0784
112.9066
109.1451
108.9513
97.7603
97.5523
86.6577
86.0733
86.0588
86.0454
51.5772
51.2921
51.0564
50.8239
CF3
Ph
HO
F
N
H
7h
f1 (ppm)

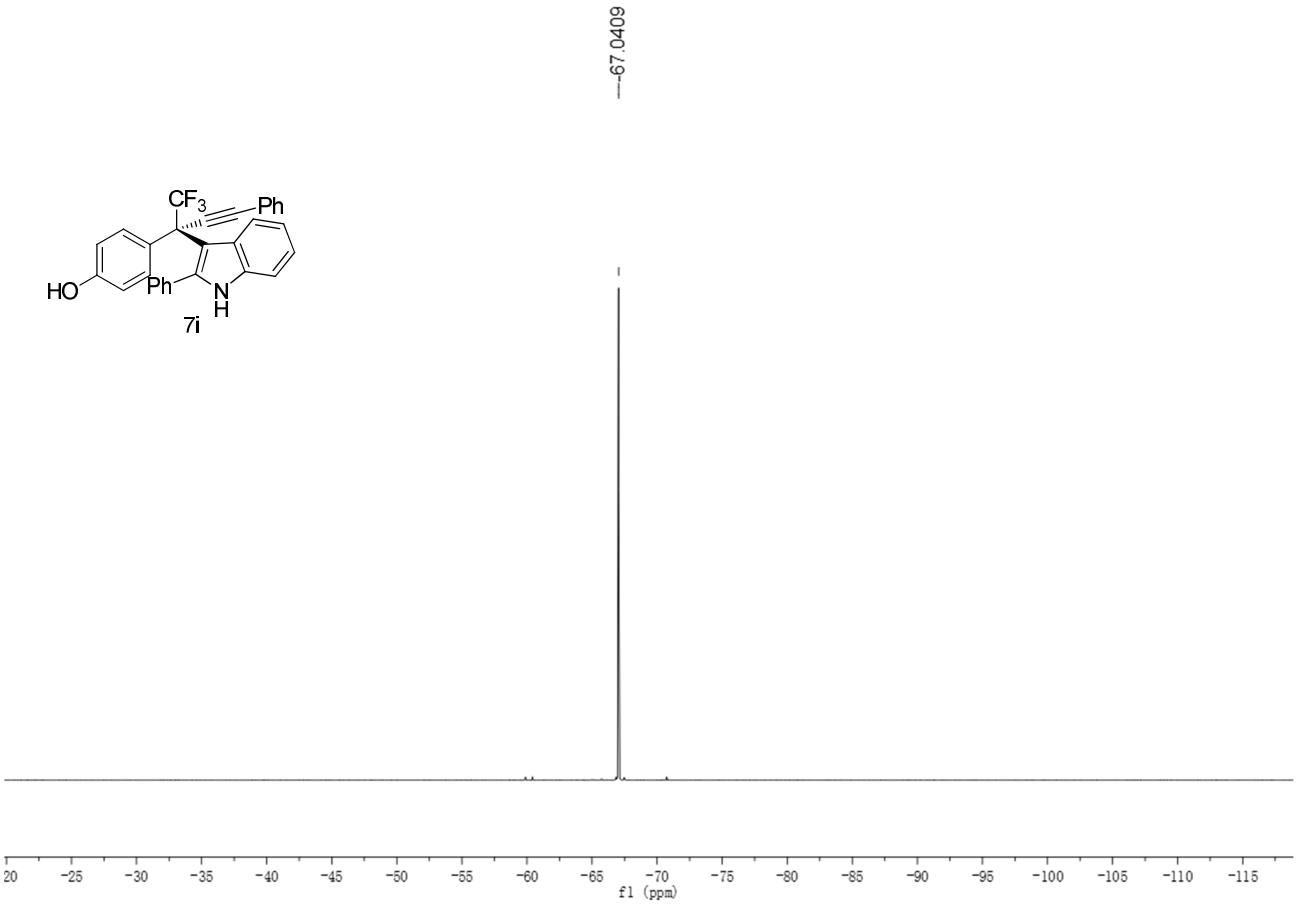

-70.7628
-120.4862
CF3
Ph
HO
N
H
F
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -105 -115 -125 -135 -145 -155
f1 (ppm)

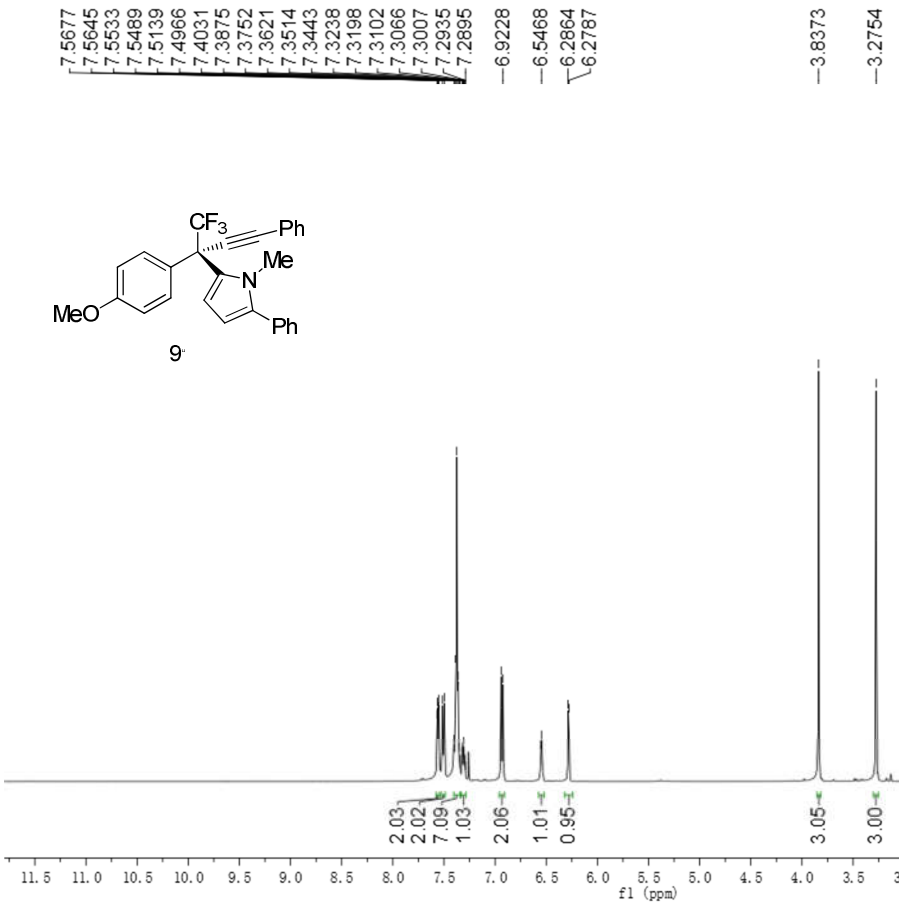
7h

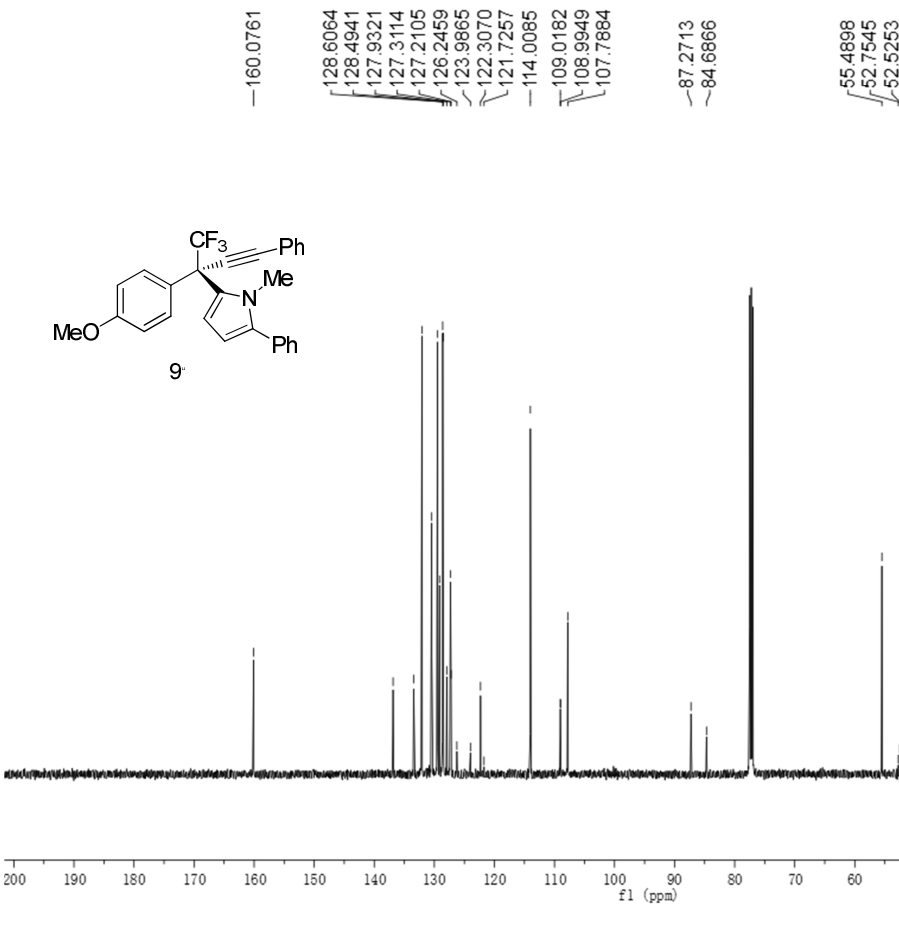

8.0655
7.3269
7.2421
7.1783
7.1061
6.6440
6.6264
5.0251
CF3
Ph
HO
Ph
N
H
0.96
2.97
0.99
1.96
0.97
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

7i


154.9035
138.7144
131.5838
128.4678
127.3411
122.6114
120.2888
115.0550
110.7467
109.2412
87.7807
87.7625
87.6359
51.9585
51.7257
51.4902
51.2559
CF3
Ph
HO
Ph
N
H
7i
f1 (ppm)

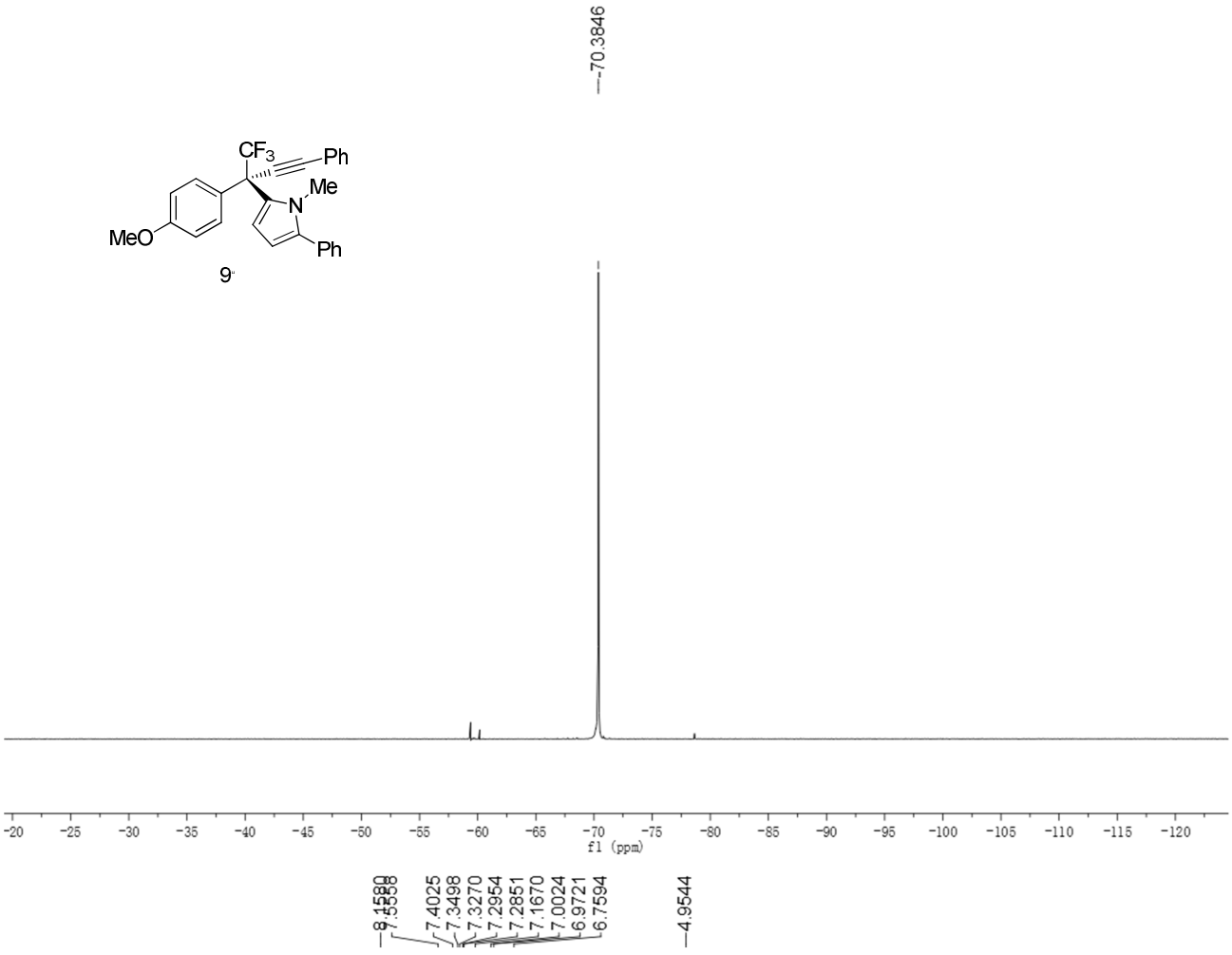

67.0409
CF3
Ph
HO
Ph
N
H
7i
f1 (ppm)

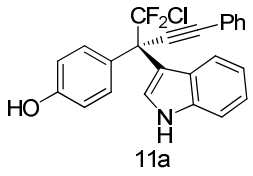

7.5677
7.5645
7.5533
7.5489
7.5139
7.4966
7.4031
7.3875
7.3752
7.3621
7.3514
7.3443
7.3238
7.3198
7.3102
7.3066
7.3007
7.2935
7.2895
6.9228
6.5468
6.2864
6.2787
3.8373
3.2754
CF3
Ph
Me
N
MeO
Ph
9
2.03
2.02
7.09
1.03
2.06
1.01
0.95
3.05
3.00
f1 (ppm)


160.0761
128.6064
128.4941
127.9321
127.3114
127.2105
126.2459
123.9865
122.3070
121.7257
114.0085
109.0182
108.9949
107.7884
87.2713
84.6866
55.4898
52.7545
52.5253
52.2939
52.0639
33.6925
CF3
Ph
Me
N
MeO
Ph
9
f1 (ppm)

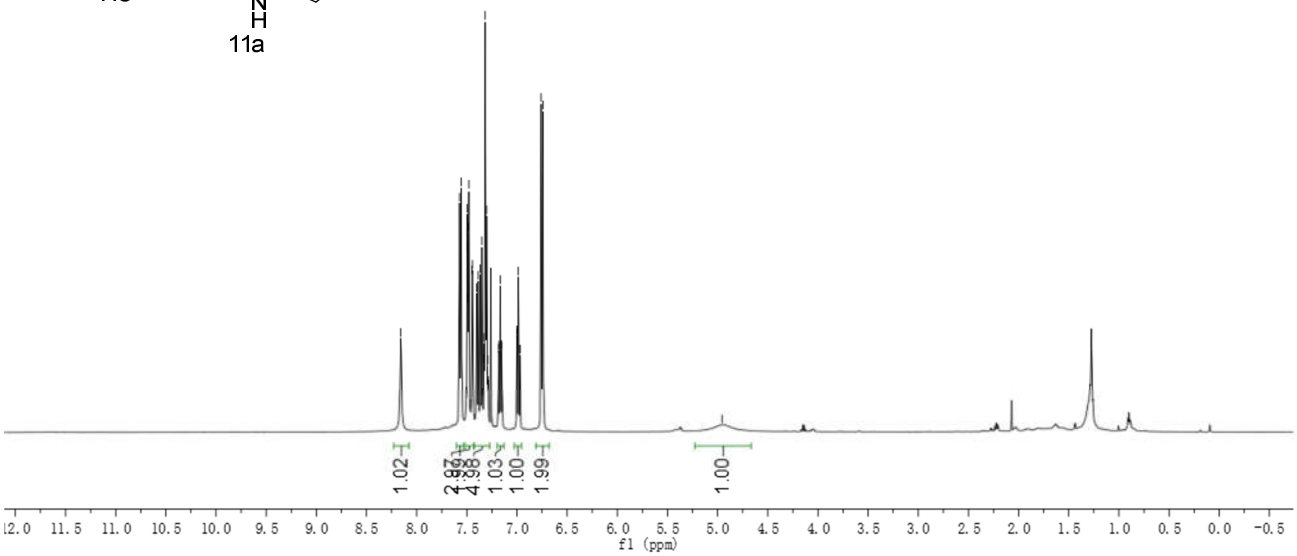
CF3
Ph
Me
N
MeO
Ph

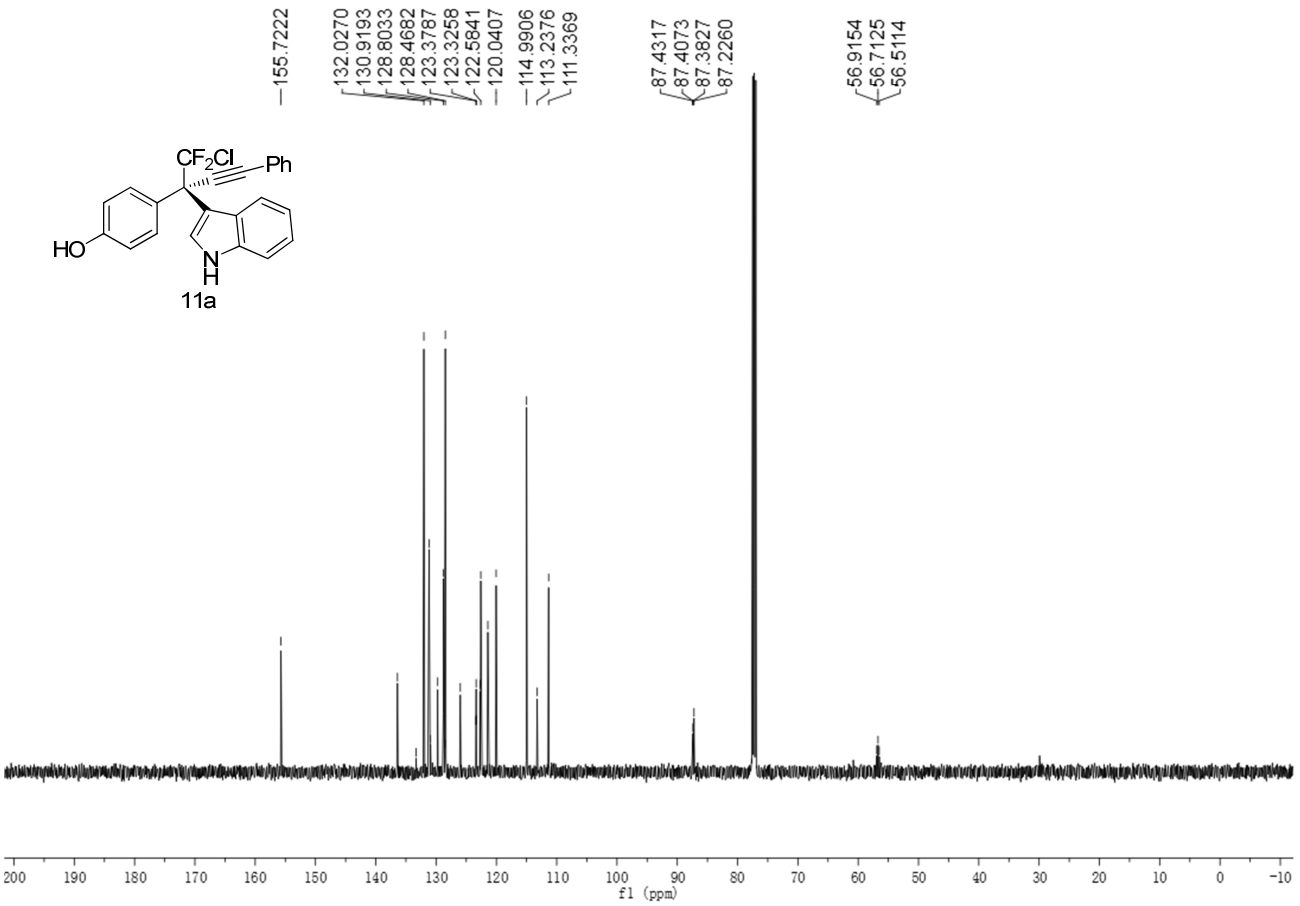
9


-70.3846
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120
f1 (ppm)
8.1580
7.5558
7.4025
7.3498
7.3270
7.2954
7.2851
7.1670
7.0024
6.9721
6.7594
4.9544


CF2Cl
Ph
HO
N
H

11a


1.02
2.97
4.98
1.03
1.00
1.99
1.00
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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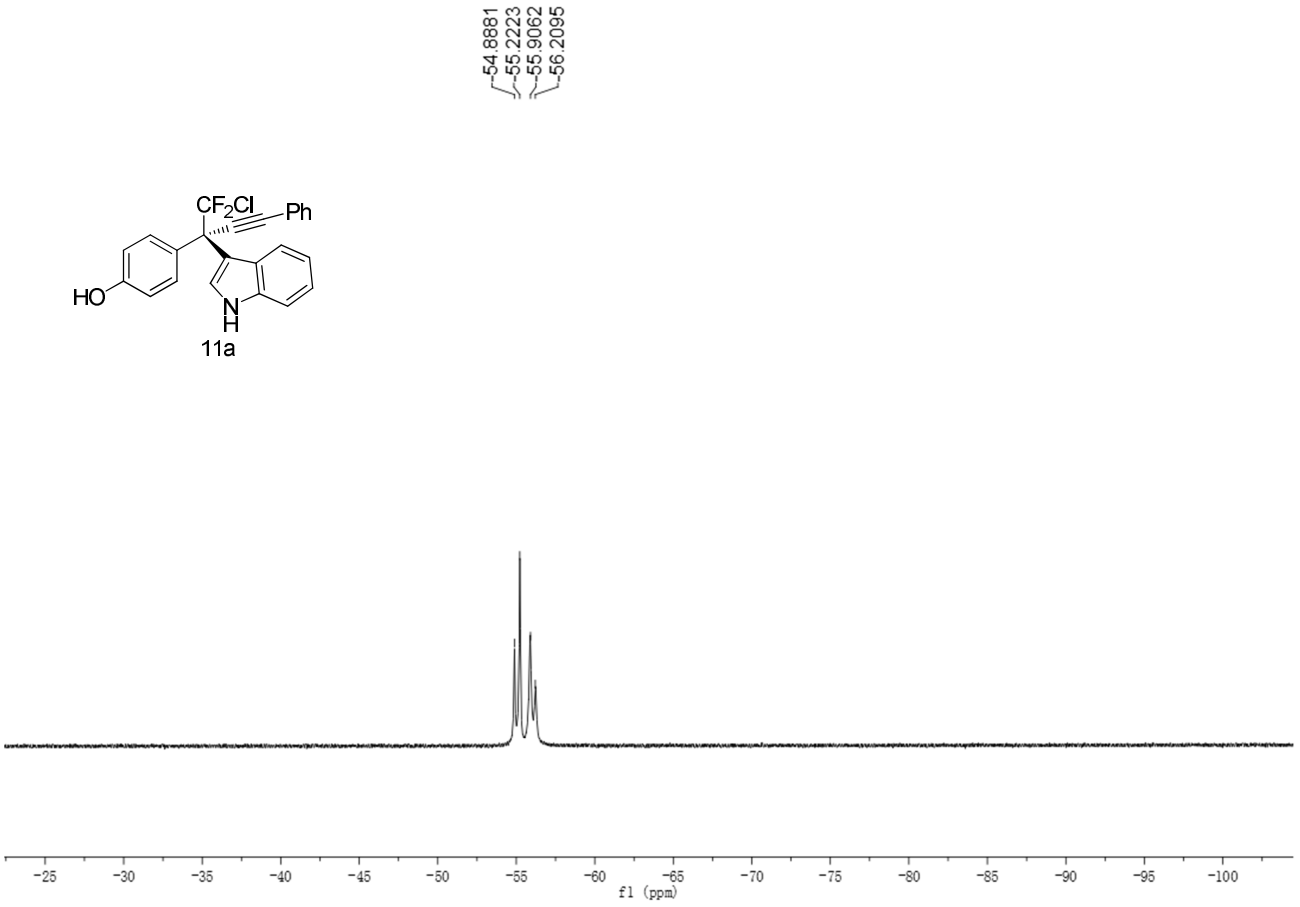
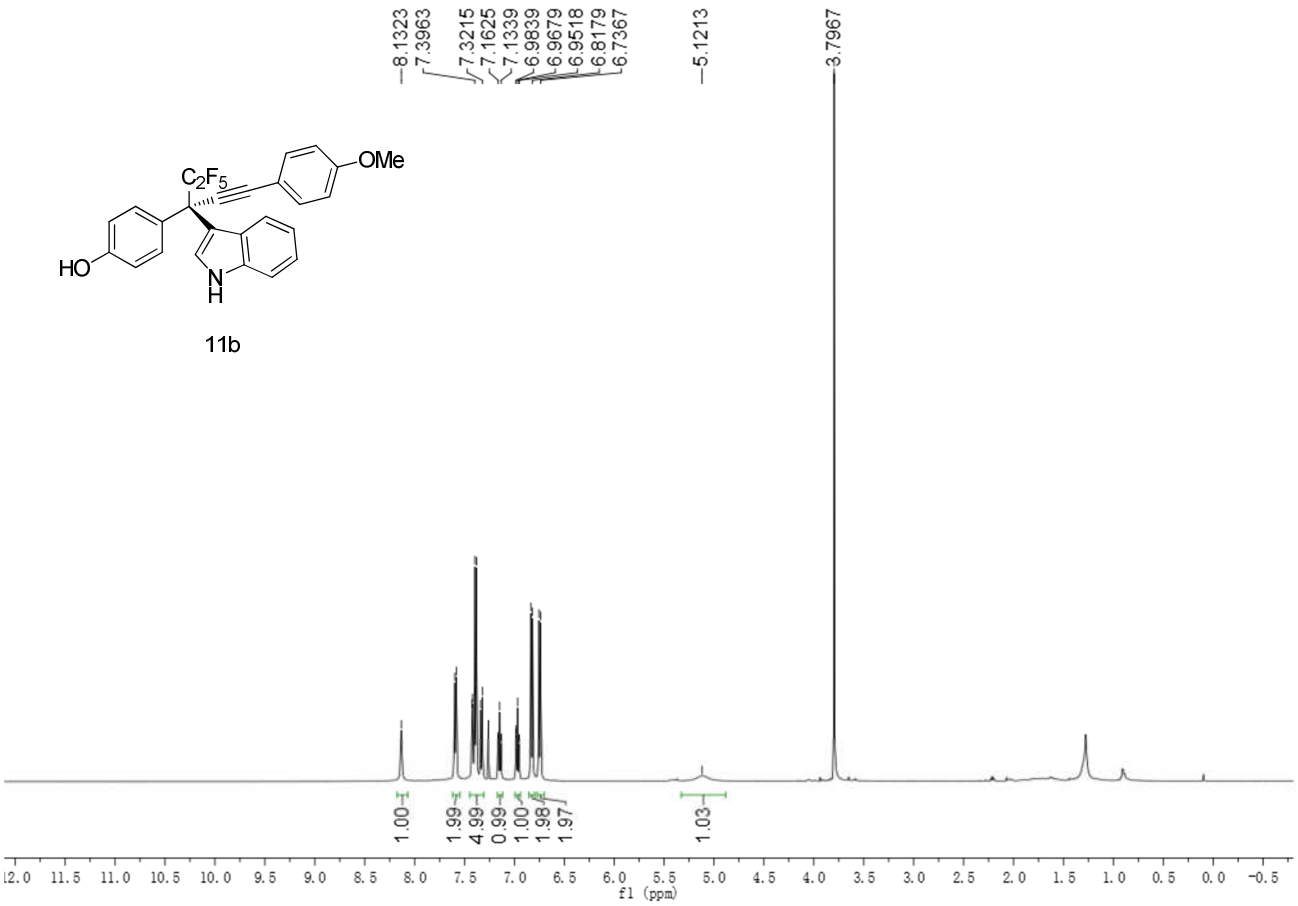
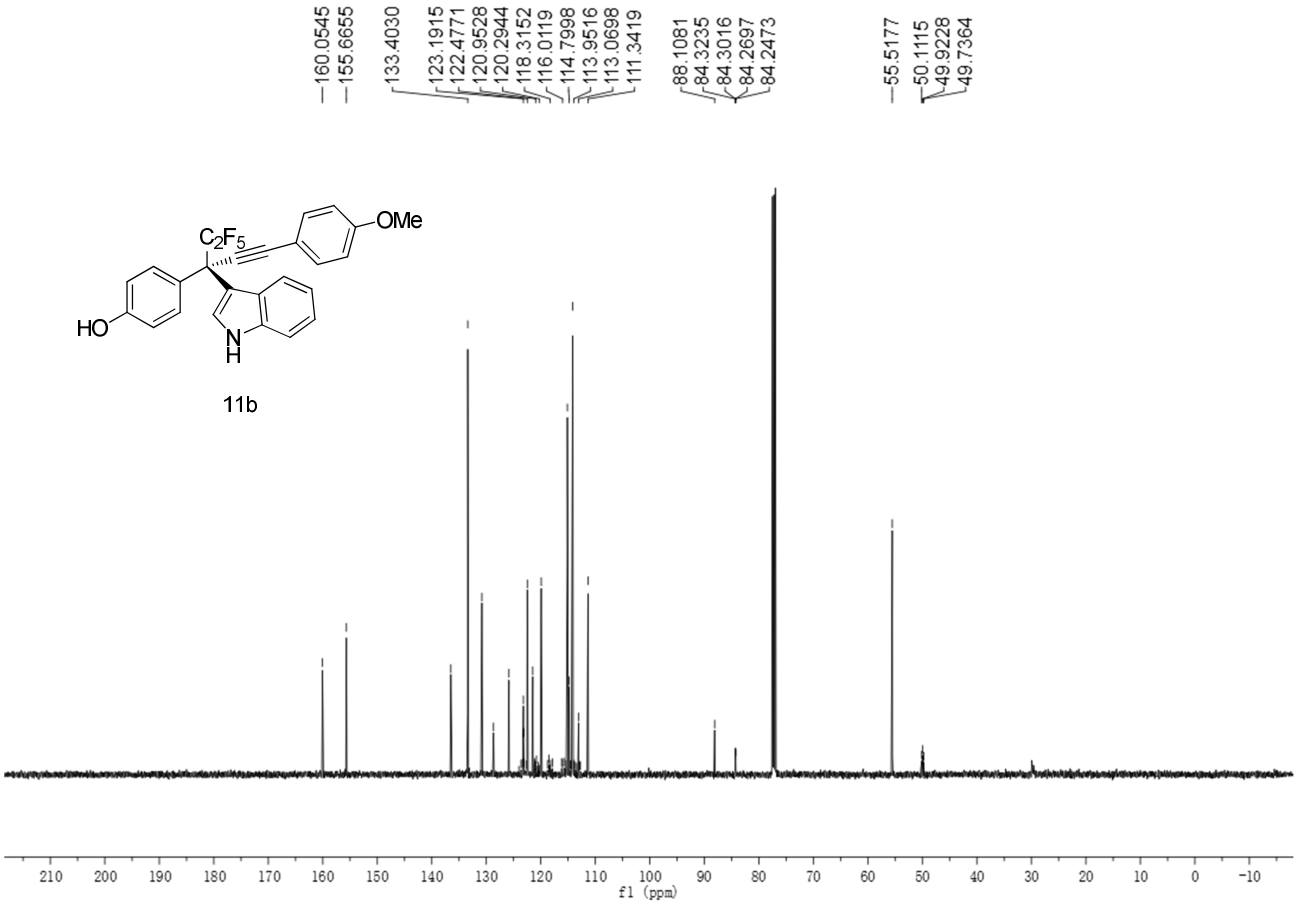
132.0270
130.9193
128.8033
128.4682
123.3787
123.3258
122.5841
120.0407
114.9906
113.2376
111.3369
87.4317
87.4073
87.3827
87.2260
56.9154
56.7125
56.5114
CF2Cl
Ph
HO
N
H
11a
f1 (ppm)


54.8881
55.2223
55.9062
56.2095
CF2Cl
Ph
HO
N
H
11a
f1 (ppm)

C2F5
OMe
HO
N
H

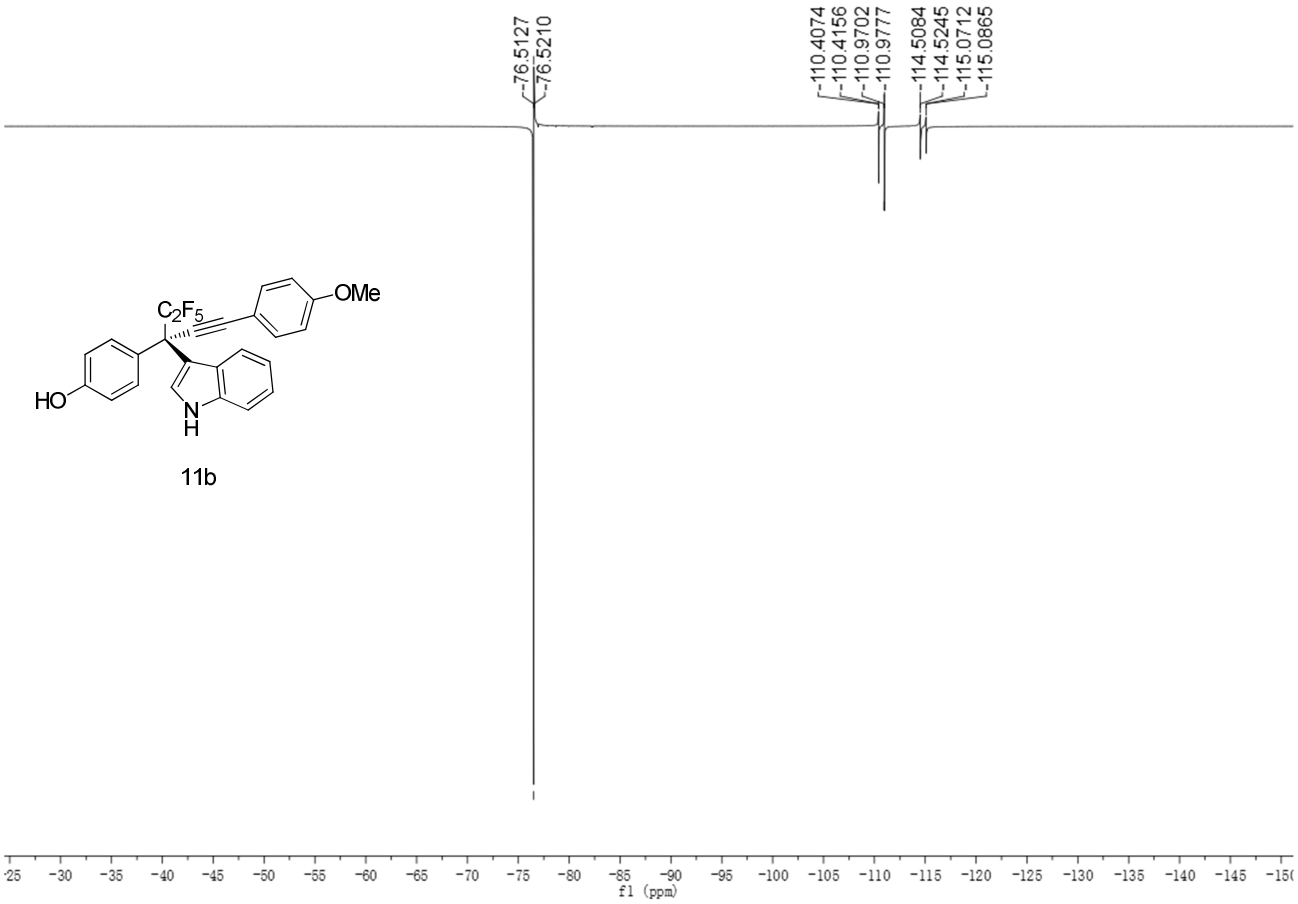
11b


8.1323
7.3963
7.3215
7.1625
7.1339
6.9839
6.9679
6.9518
6.8179
6.7367
5.1213
3.7967
1.00
1.99
4.99
0.99
1.00
1.98
1.97
1.03
f1 (ppm)

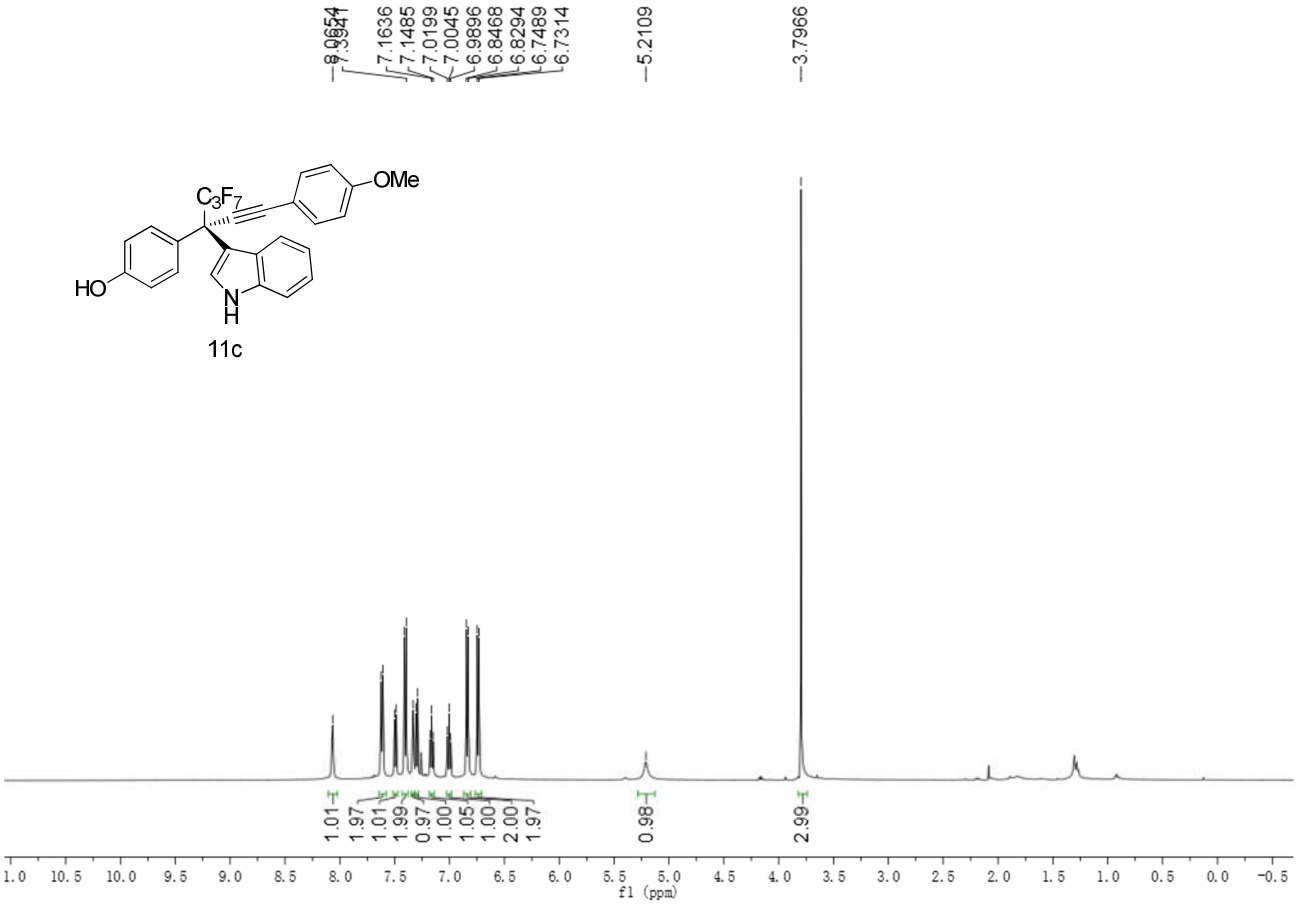

160.0545
155.6655
133.4030
123.1915
122.4771
120.9528
120.2944
118.3152
116.0119
114.7998
113.9516
113.0698
111.3419
88.1081
84.3235
84.3016
84.2697
84.2473
55.5177
50.1115
49.9228
49.7364
f1 (ppm)

C2F5
OMe
HO
N
H

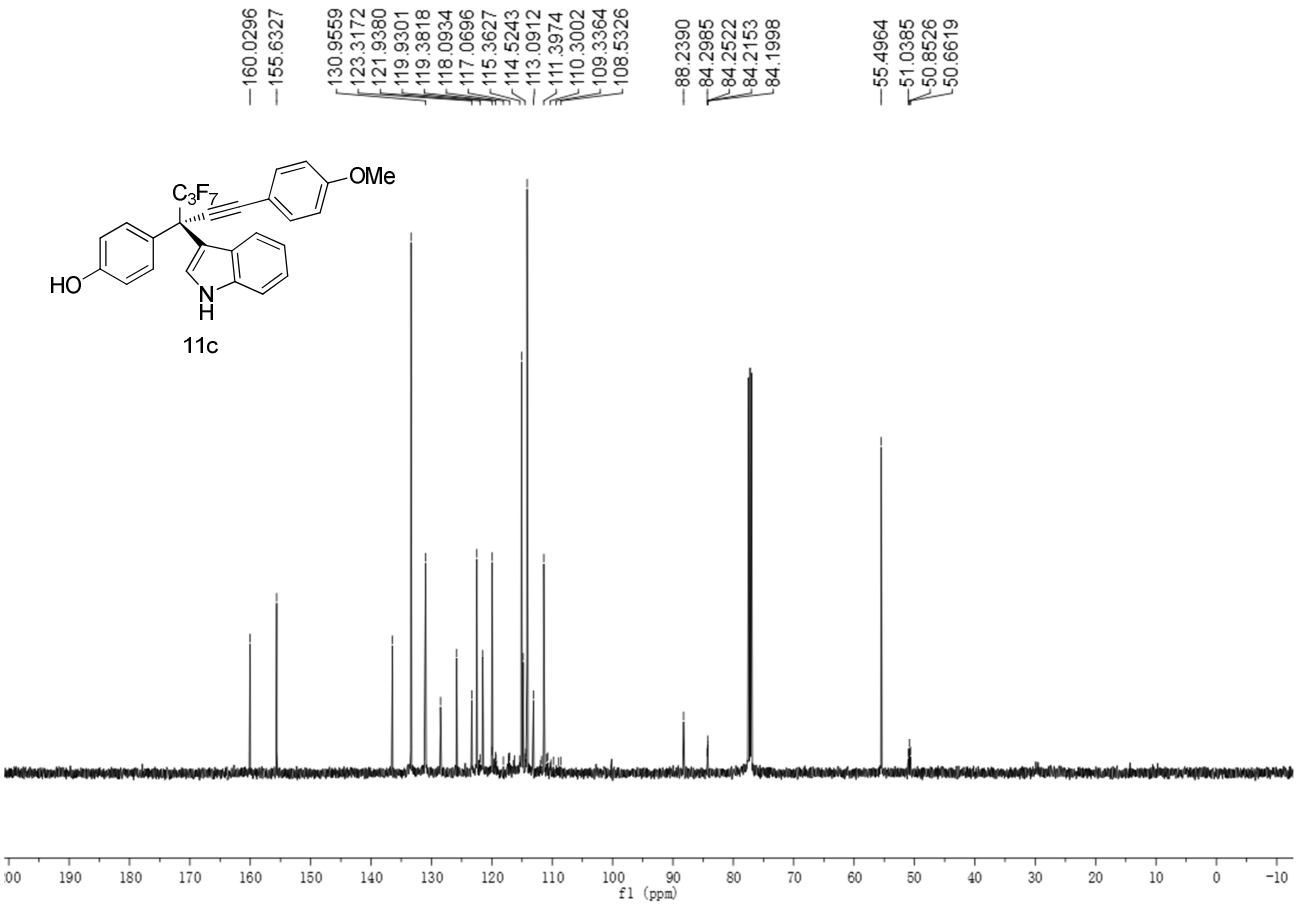
11b

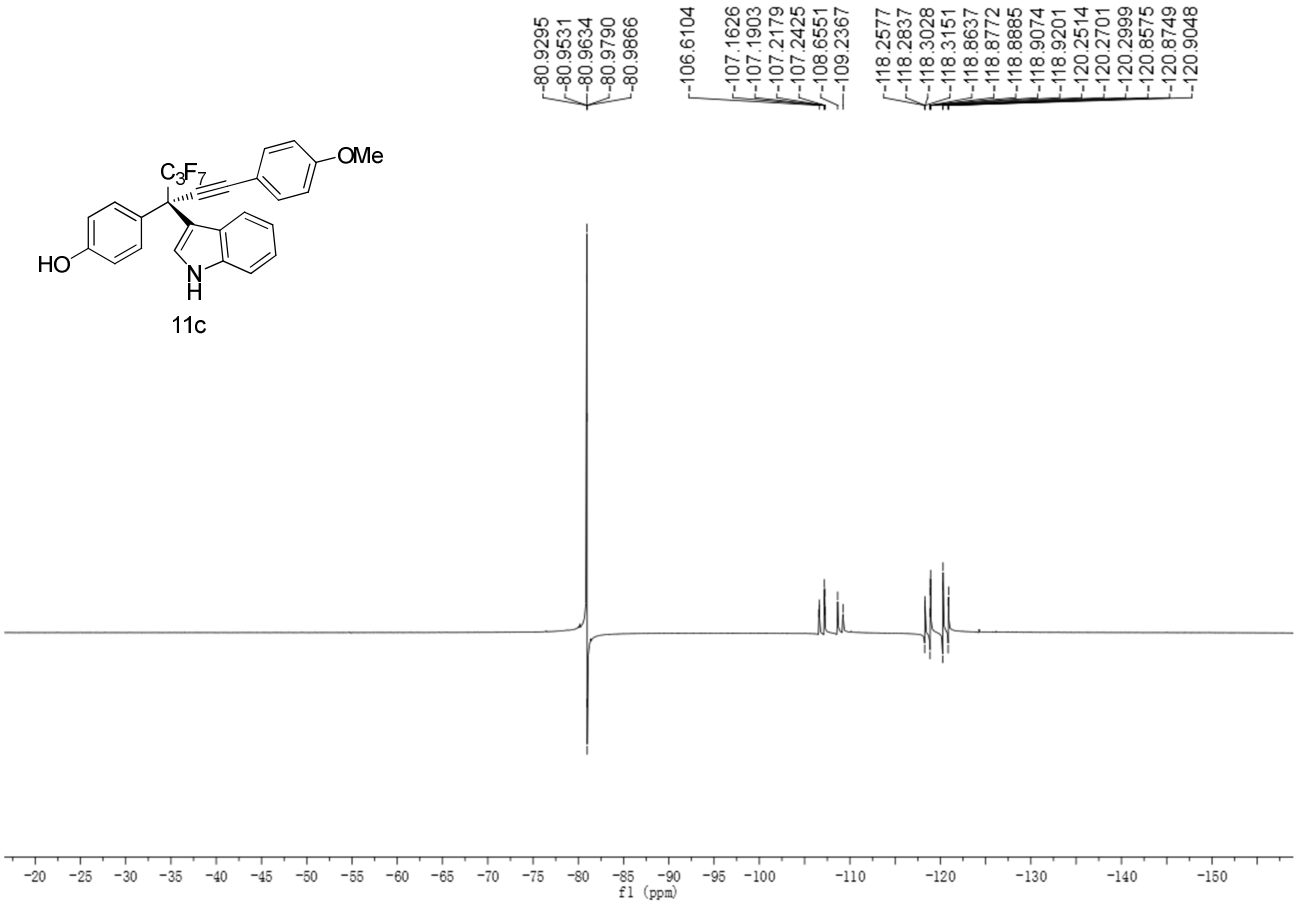

76.5127
76.5210
110.4074
110.4156
110.9702
110.9777
114.5084
114.5245
115.0712
115.0865
OMe
C_2F_5
HO
N
H
f1 (ppm)

11b


7.1636
7.1485
7.0199
7.0045
6.9896
6.8468
6.8294
6.7489
6.7314
5.2109
3.7966
OMe
C_3F_7
HO
N
H
1.01
1.97
1.01
1.99
0.97
1.00
1.05
1.00
2.00
1.97
0.98
2.99
f1 (ppm)

11c


160.0296
155.6327
130.9559
123.3172
121.9380
119.9301
119.3818
118.0934
117.0696
115.3627
114.5243
113.0912
111.3974
110.3002
109.3364
108.5326
88.2390
84.2985
84.2522
84.2153
84.1998
55.4964
51.0385
50.8526
50.6619
OMe
C_3F_7
HO
N
H
11c
f1 (ppm)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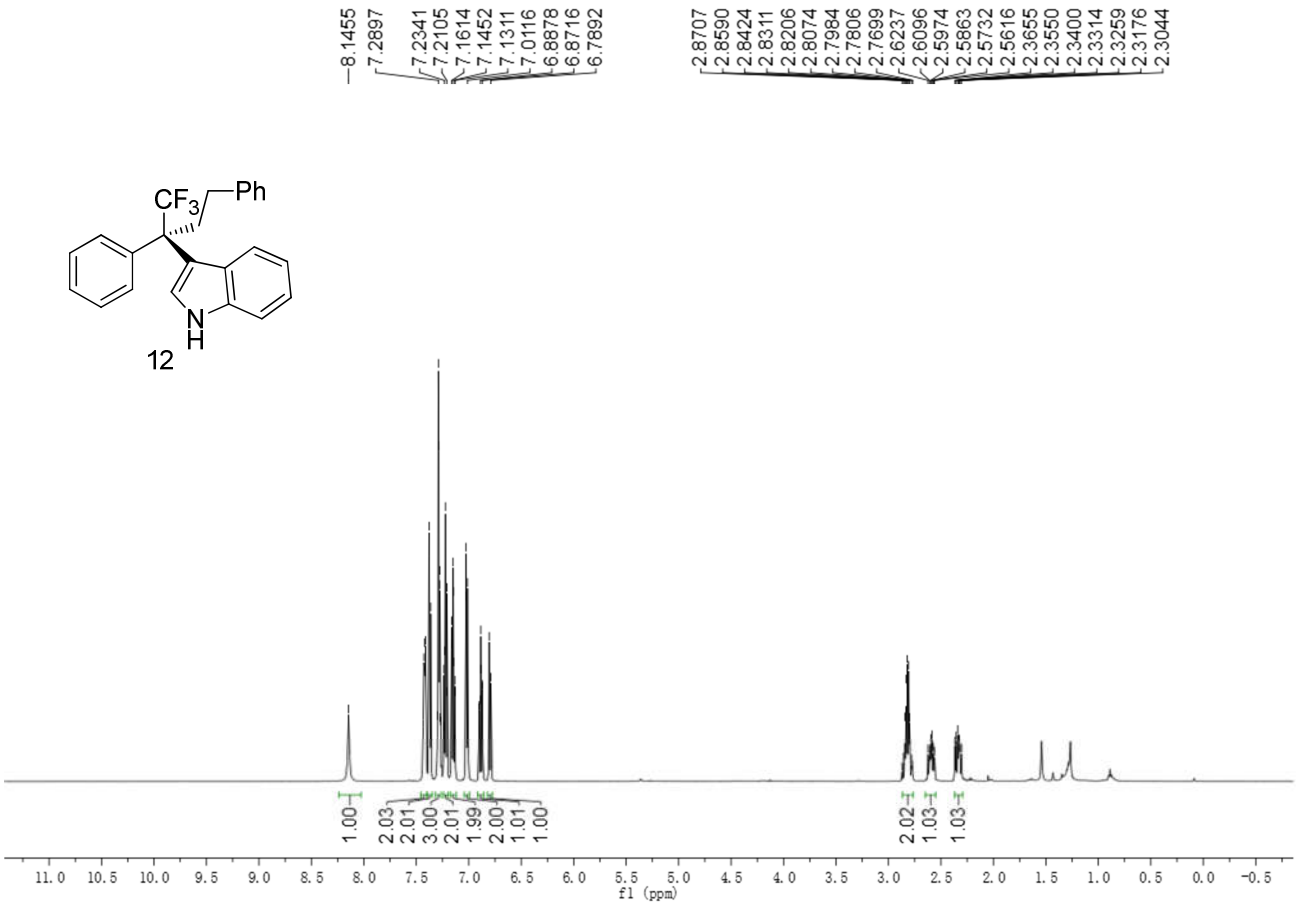
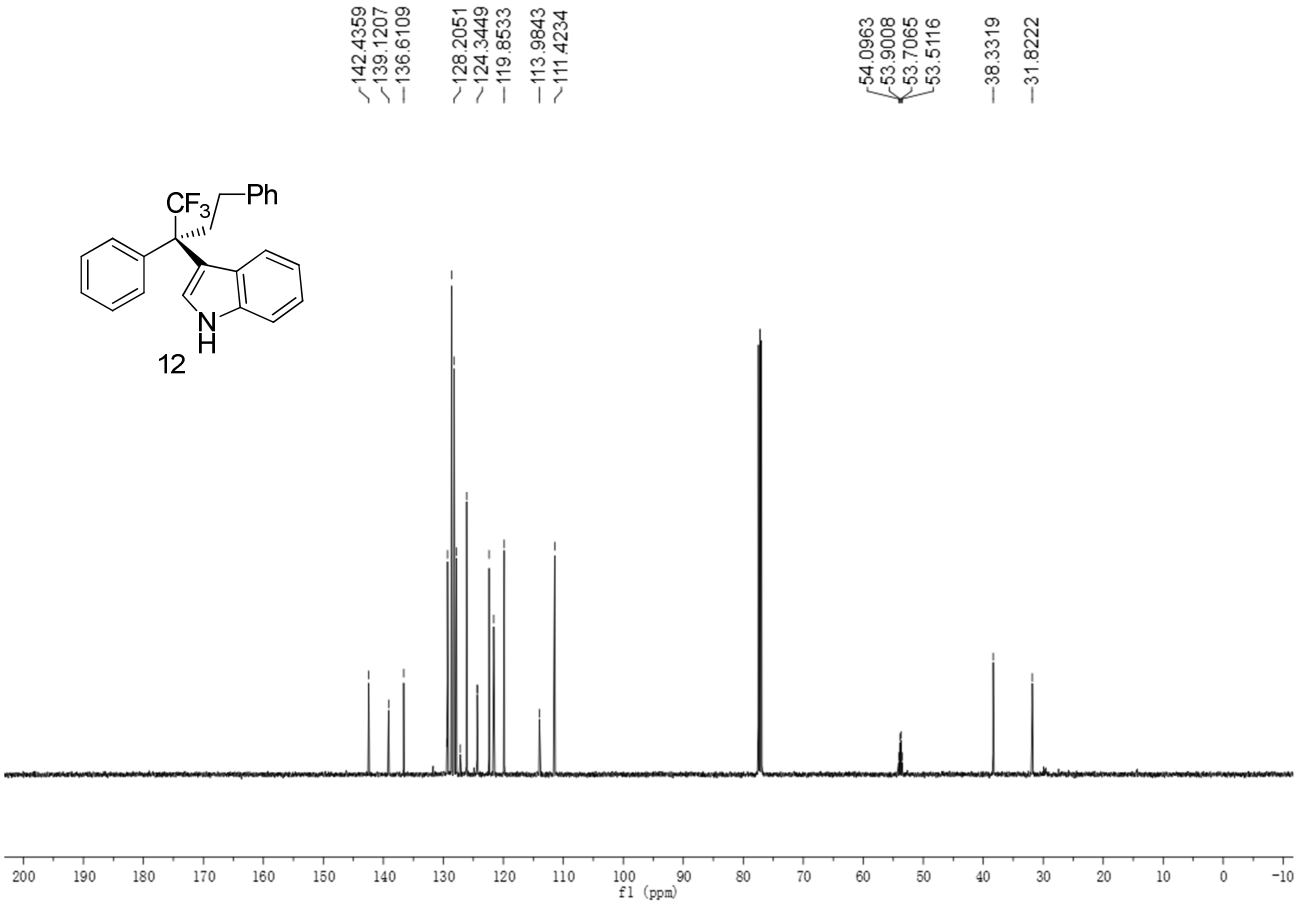
80.9531
80.9634
80.9790
80.9866
106.6104
107.1626
107.1903
107.2179
107.2425
108.6551
109.2367
118.2577
118.2837
118.3028
118.3151
118.8637
118.8772
118.8885
118.9074
118.9201
120.2514
120.2701
120.2999
120.8575
120.8749
120.9048
OMe
C_3F_7
HO
N
H
11c
f1 (ppm)


8.1455
7.2897
7.2341
7.2105
7.1614
7.1452
7.1311
7.0116
6.8878
6.8716
6.7892
2.8707
2.8590
2.8424
2.8311
2.8206
2.8074
2.7984
2.7806
2.7699
2.6237
2.6096
2.5974
2.5863
2.5732
2.5616
2.3655
2.3550
2.3400
2.3314
2.3259
2.3176
2.3044
CF3
Ph
N
H
12
1.00
2.03
2.01
3.00
2.01
1.99
2.00
1.01
1.00
2.02
1.03
1.03
f1 (ppm)


142.4359
139.1207
136.6109
128.2051
124.3449
119.8533
113.9843
111.4234
54.0963
53.9008
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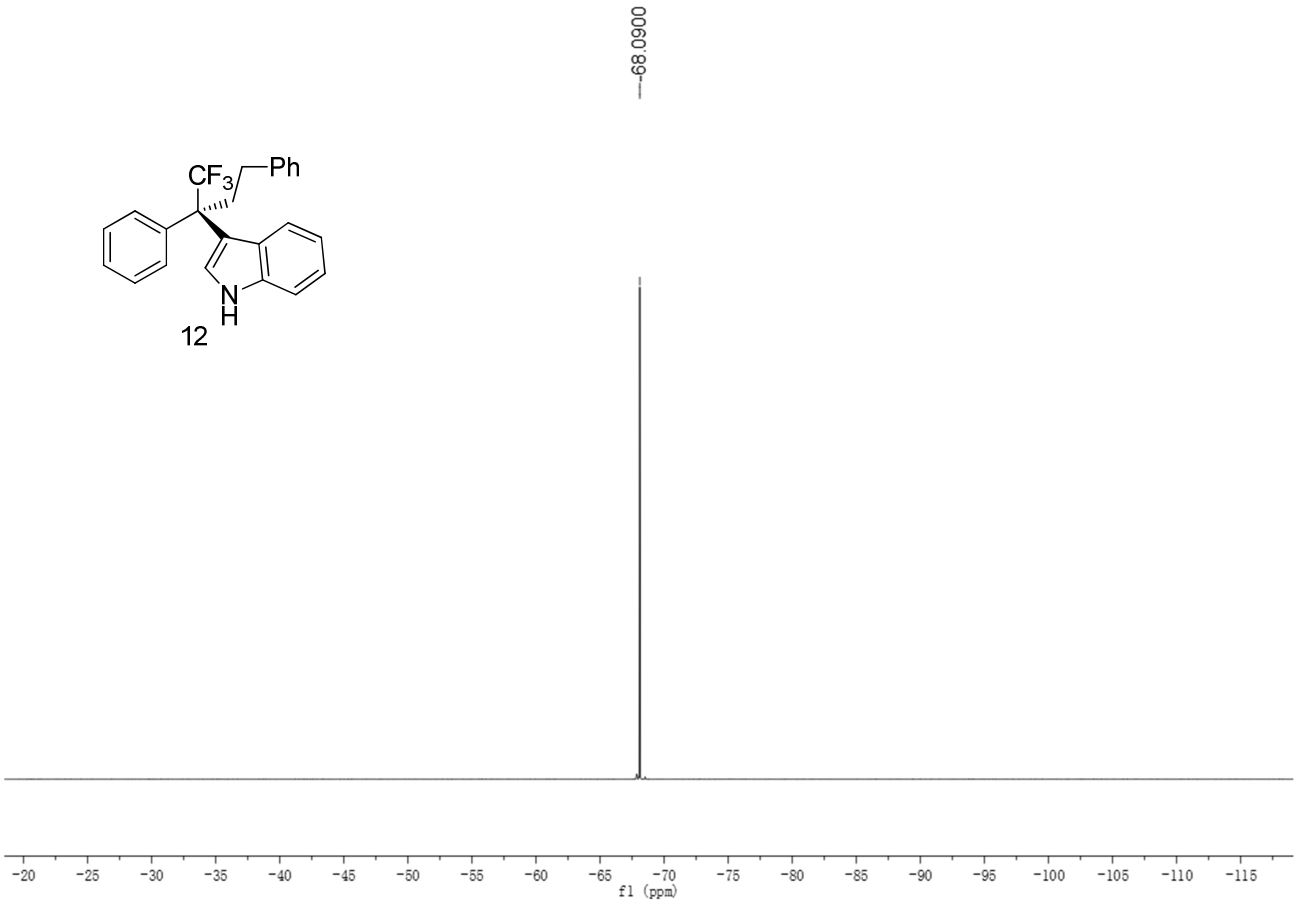
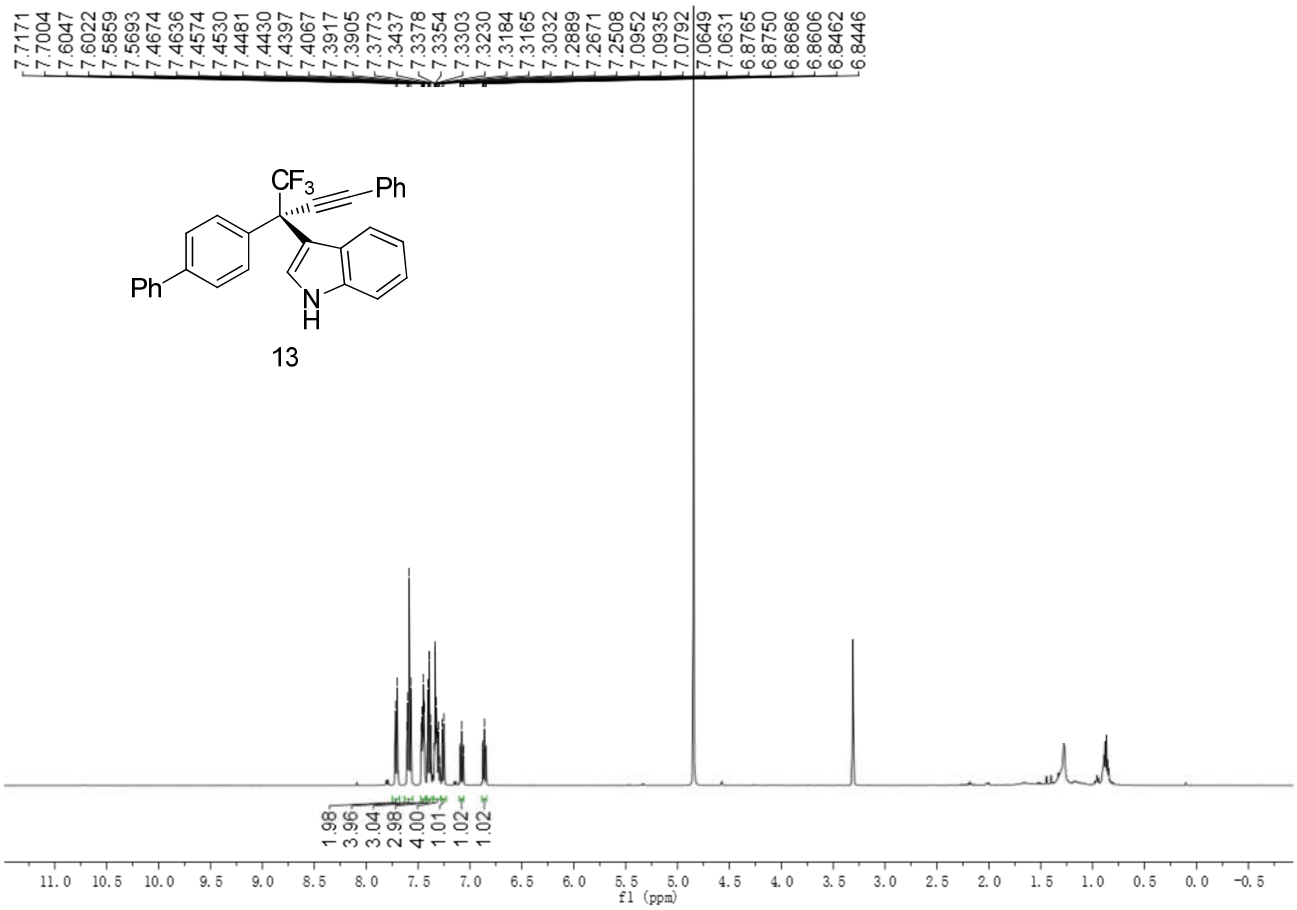
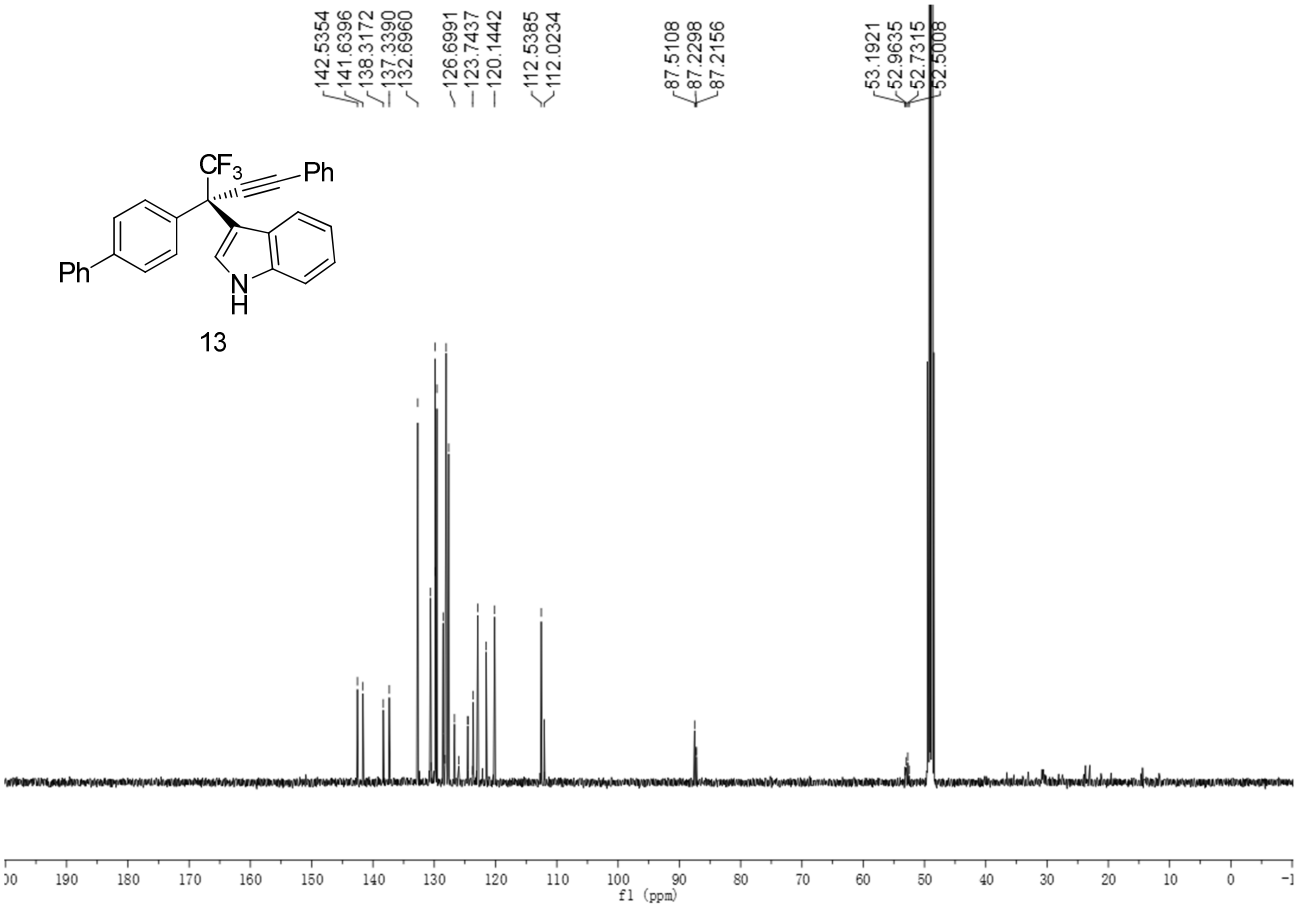
31.8222
CF3
Ph
N
H
12
f1 (ppm)


-68.0900
CF3
Ph
N
H
12
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115
f1 (ppm)


7.7171
7.7004
7.6047
7.6022
7.5859
7.5693
7.4674
7.4636
7.4574
7.4530
7.4481
7.4430
7.4397
7.4067
7.3917
7.3905
7.3773
7.3437
7.3378
7.3354
7.3303
7.3230
7.3184
7.3165
7.3032
7.2889
7.2671
7.2508
7.0952
7.0935
7.0792
7.0649
7.0631
6.8765
6.8750
6.8686
6.8606
6.8462
6.8446
CF3
Ph
Ph
N
H
13
1.98
3.96
3.04
2.98
4.00
1.01
1.02
1.02
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


142.5354
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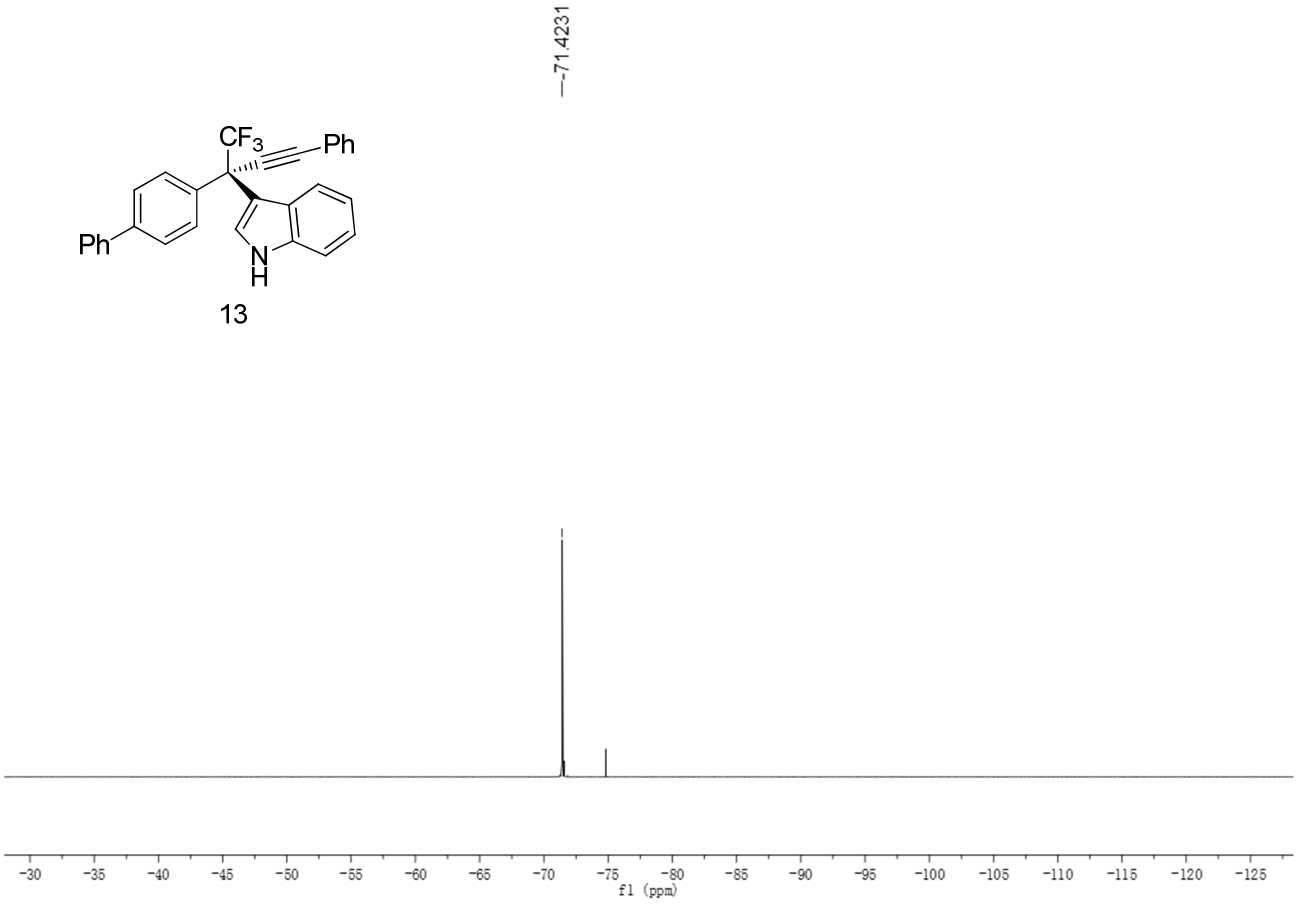
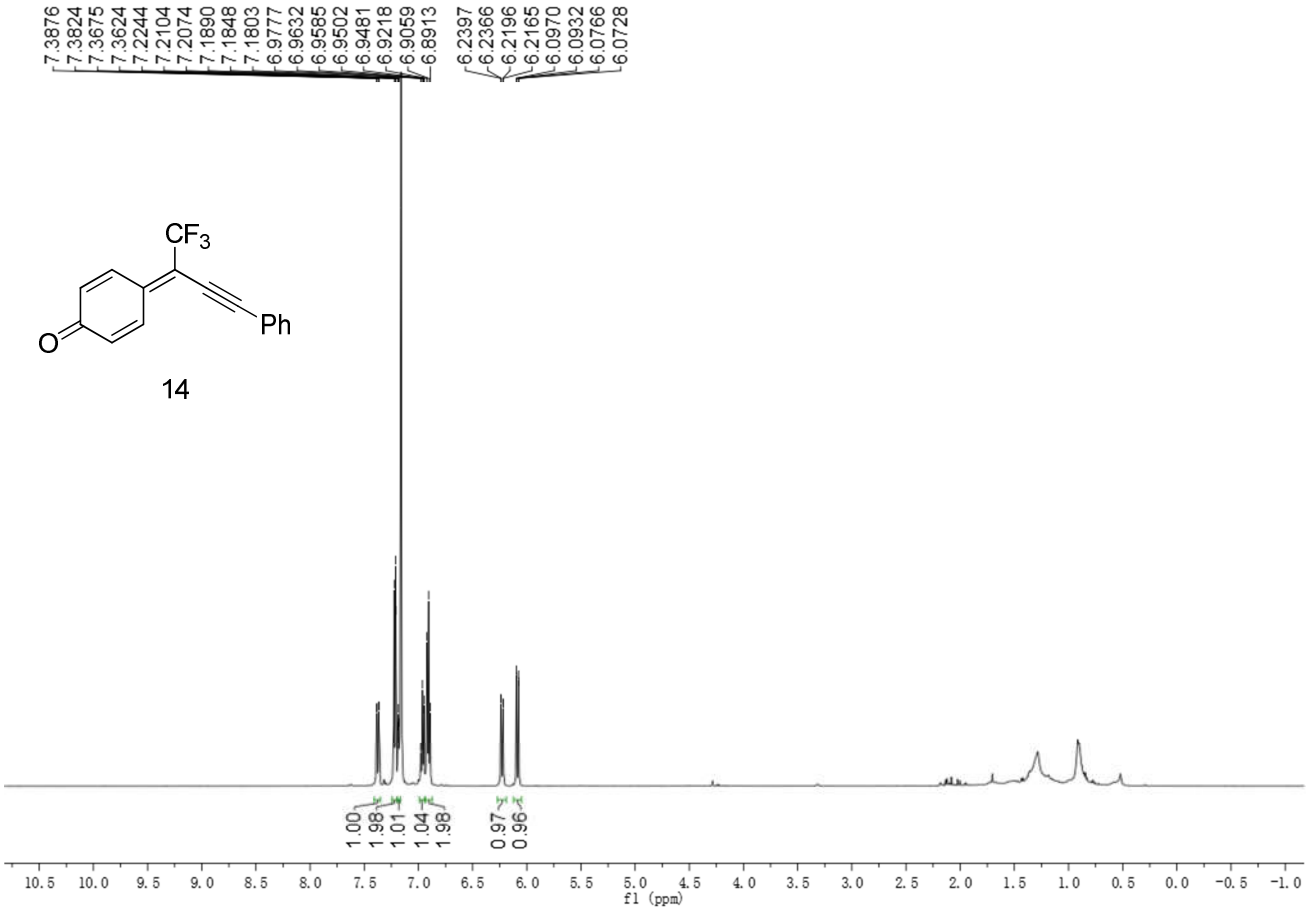
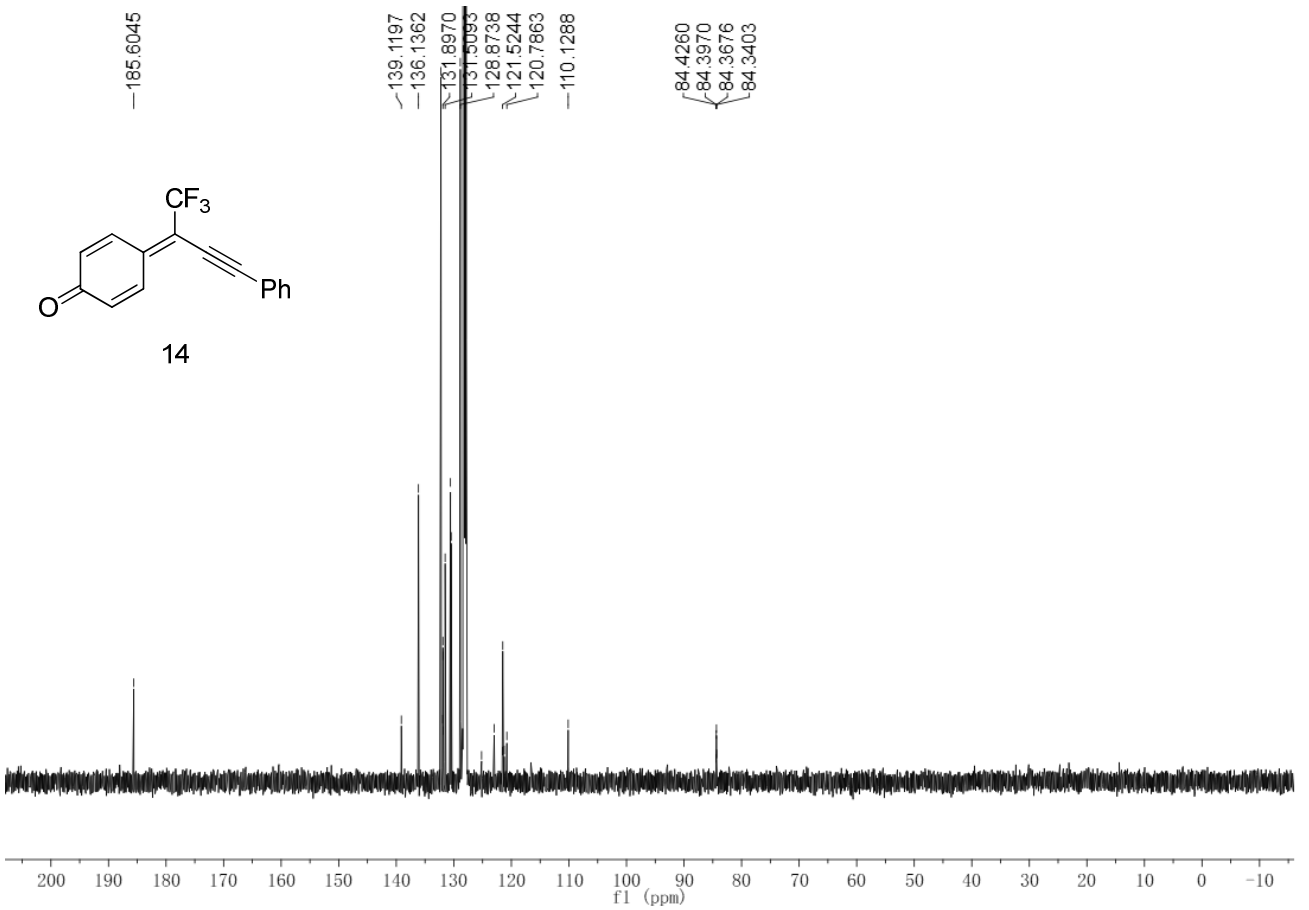
138.3172
137.3390
132.6960
126.6991
123.7437
120.1442
112.5385
112.0234
87.5108
87.2298
87.2156
53.1921
52.9635
52.7315
52.5008
CF3
Ph
Ph
N
H
f1 (ppm)

13


-71.4231
CF3
Ph
Ph
N
H
f1 (ppm)

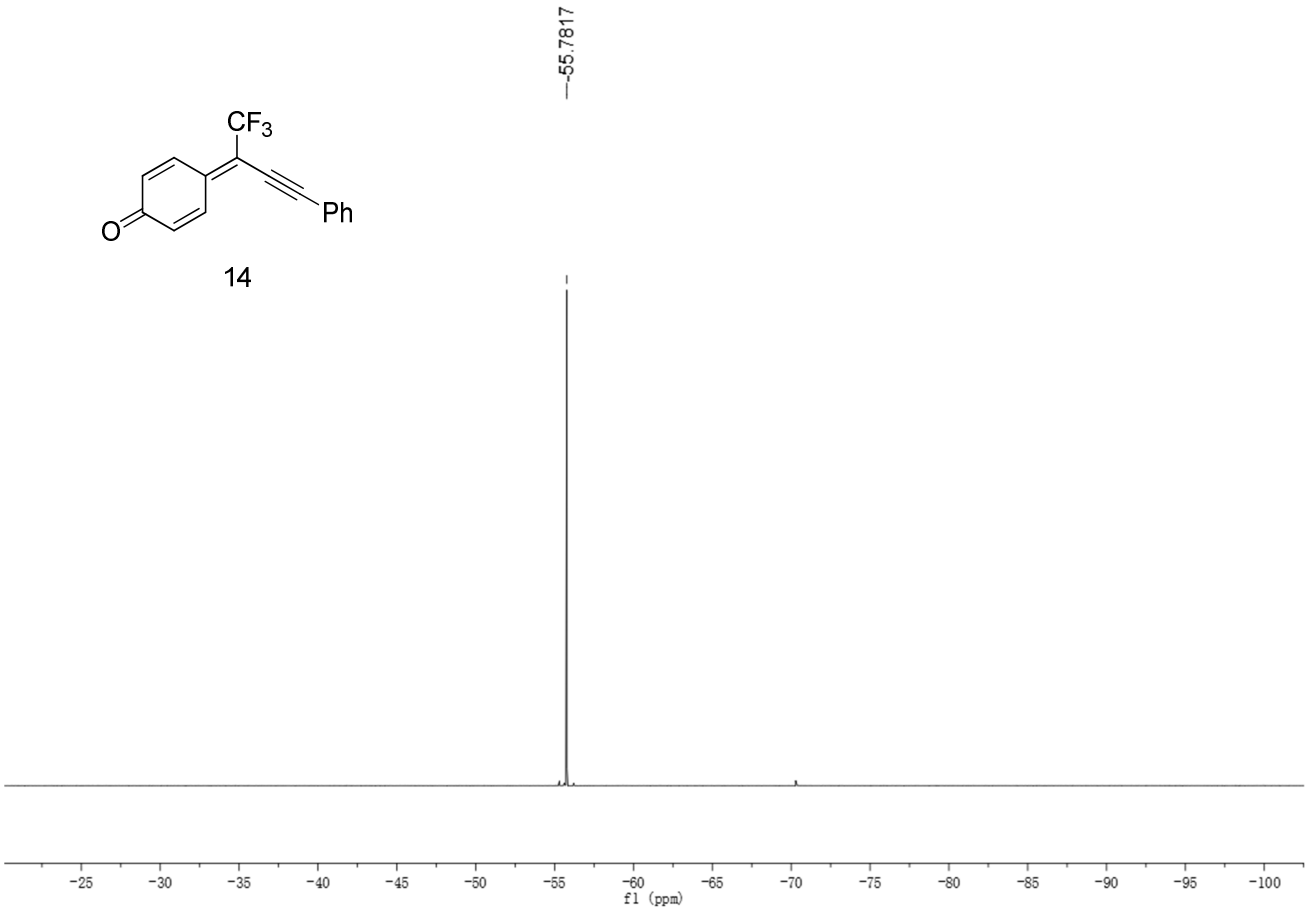
13


7.3876
7.3824
7.3675
7.3624
7.2244
7.2104
7.2074
7.1890
7.1848
7.1803
6.9777
6.9632
6.9585
6.9502
6.9481
6.9218
6.9059
6.8913
6.2397
6.2366
6.2196
6.2165
6.0970
6.0932
6.0766
6.0728
CF3
O
Ph
14
1.00
1.98
1.01
1.04
1.98
0.97
0.96
f1 (ppm)


185.6045
139.1197
136.1362
131.8970
131.5093
128.8738
121.5244
120.7863
110.1288
84.4260
84.3970
84.3676
84.3403
CF3
O
Ph
14
f1 (ppm)

CF3
O
Ph

14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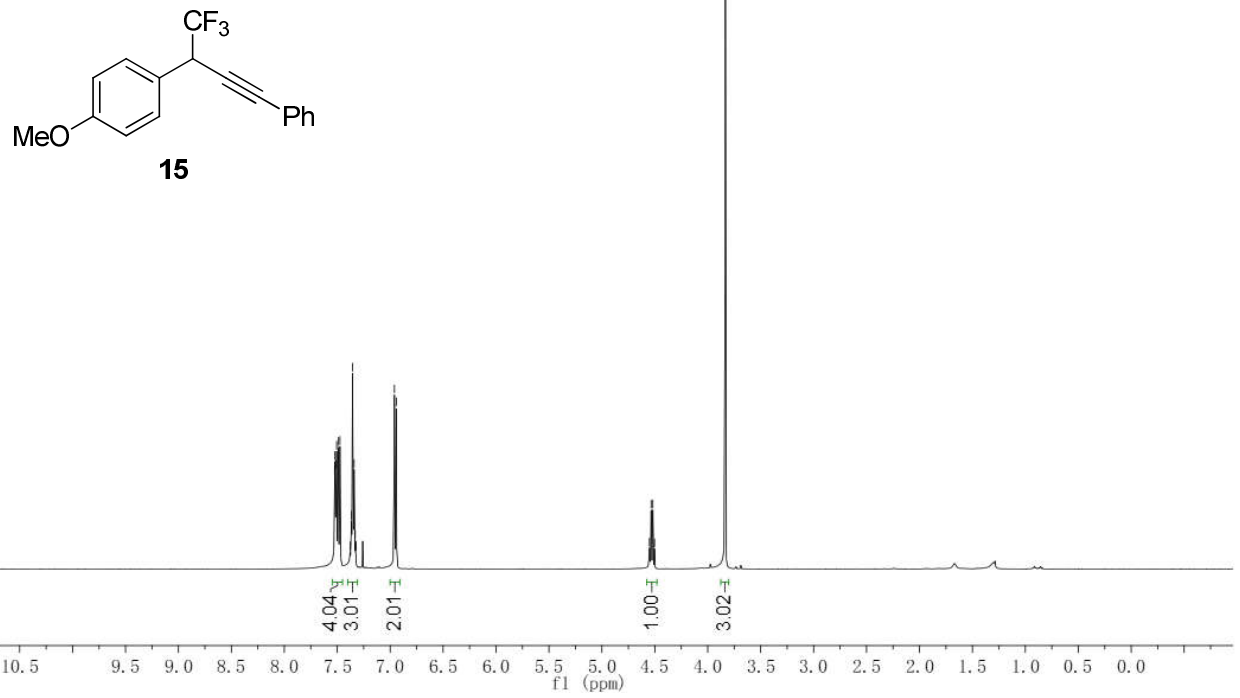
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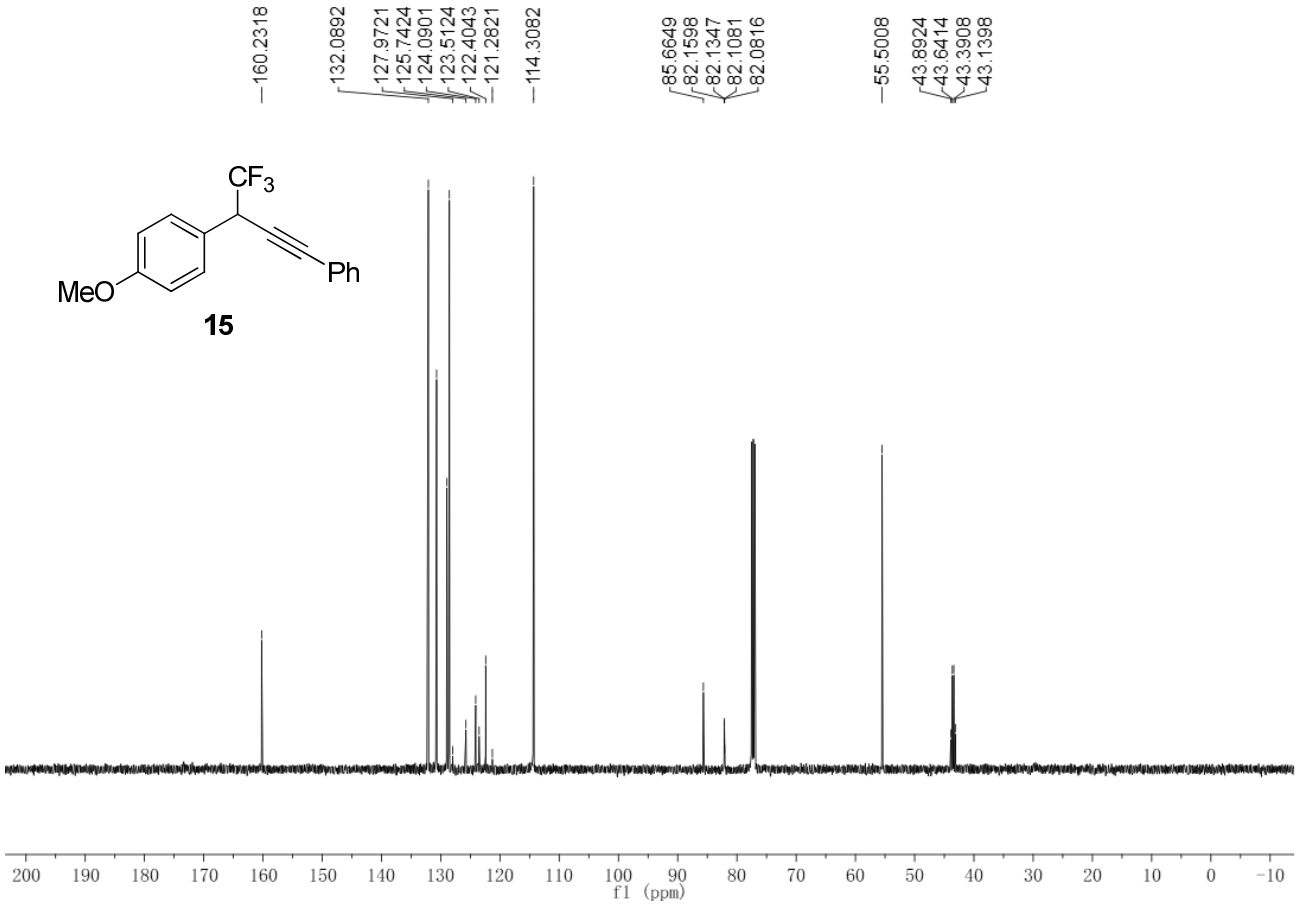
4.04
3.01
2.01
1.00
3.02
10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

CF3
MeO
Ph

15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43.6414
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CF3
MeO
Ph
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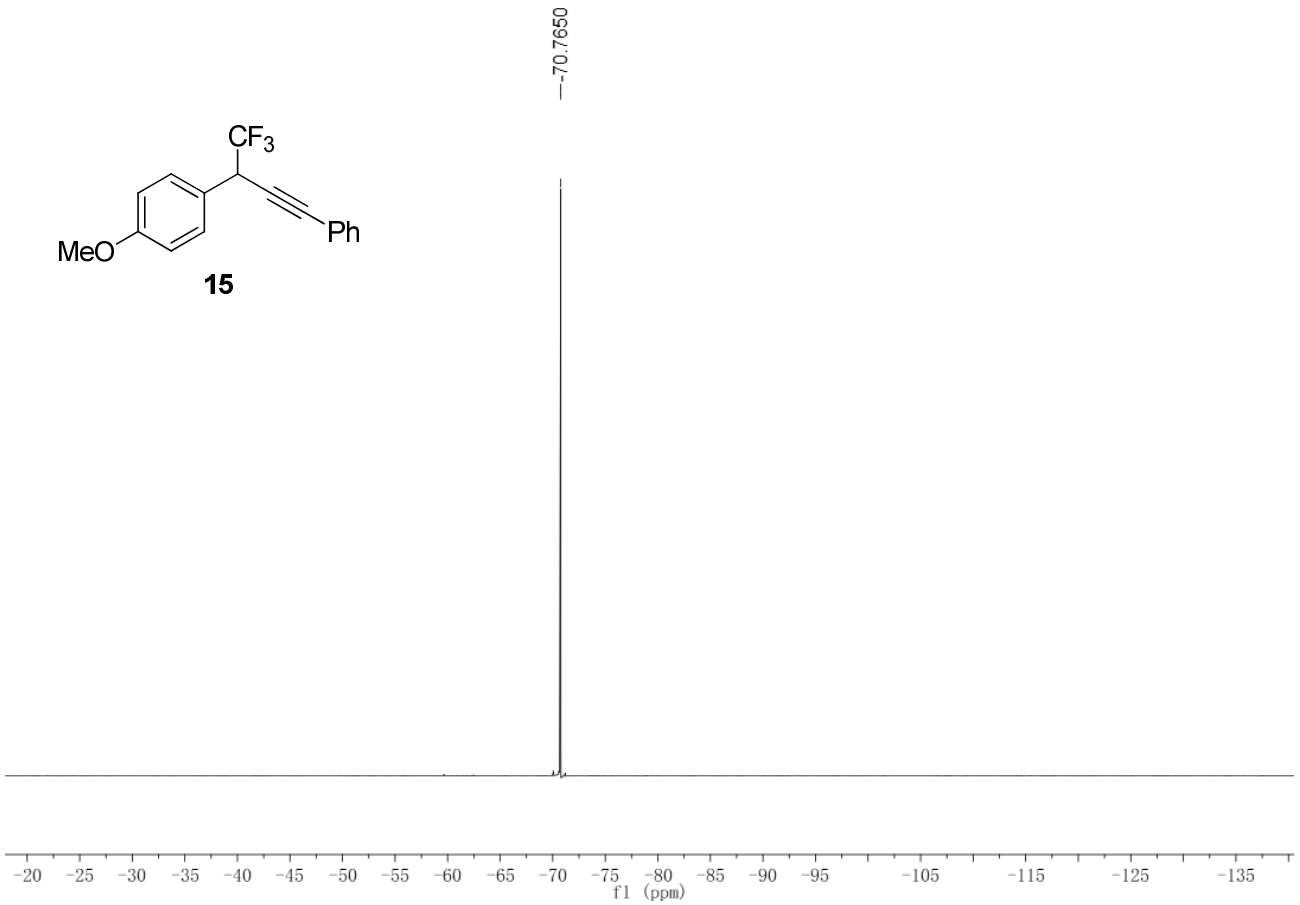
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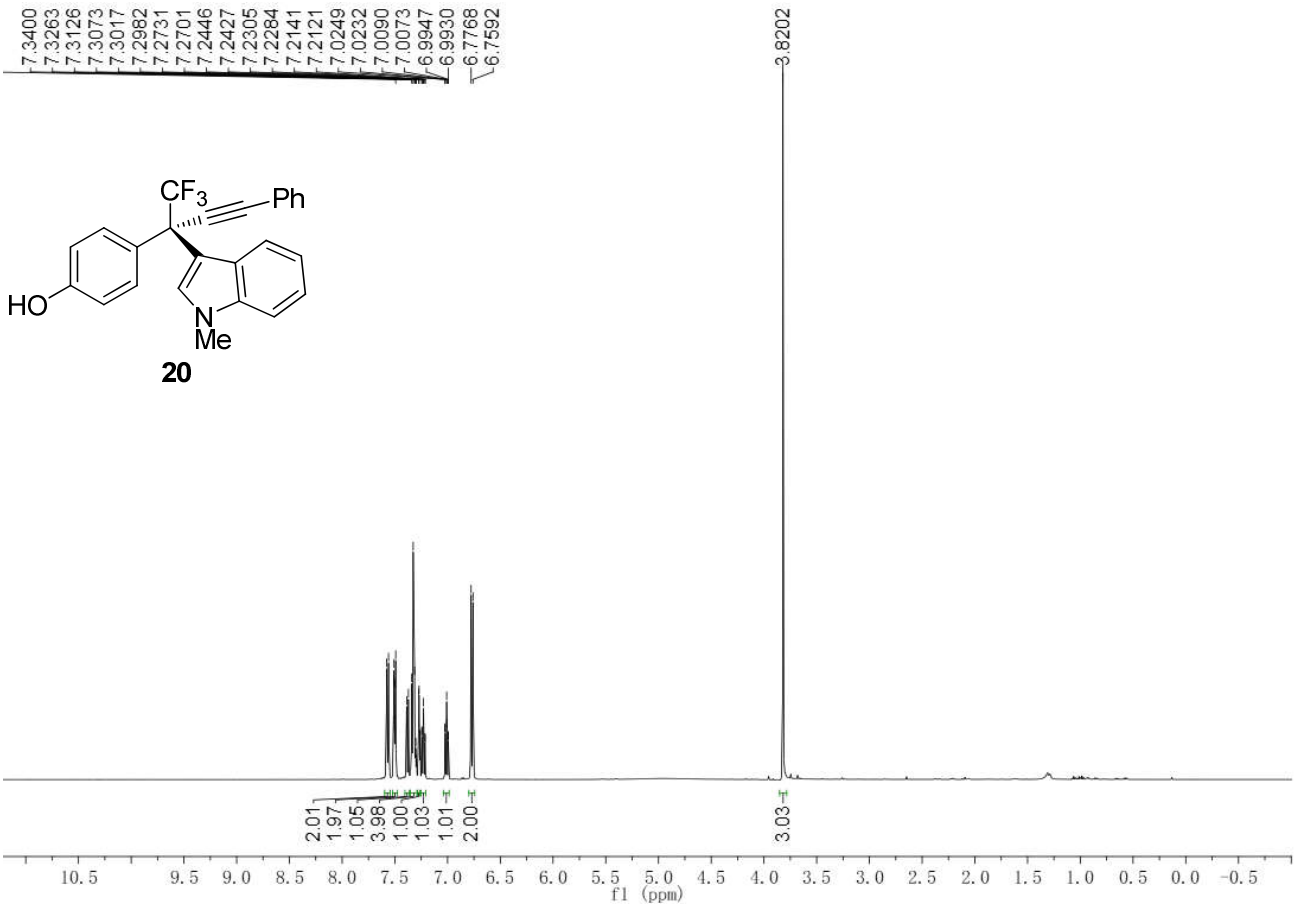
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CF3
Ph
HO
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1.01
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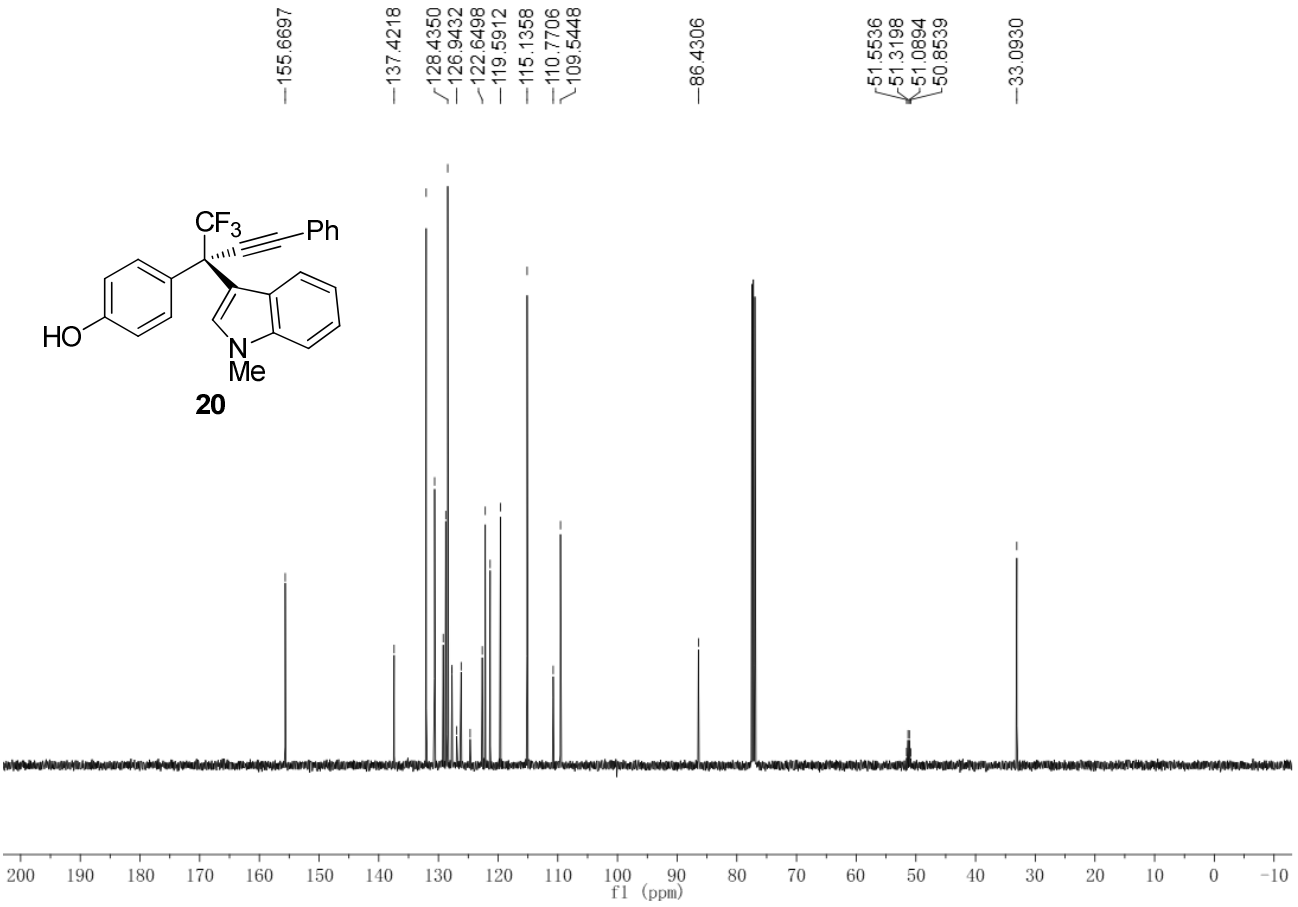
3.03
f1 (ppm)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CF3
Ph
HO
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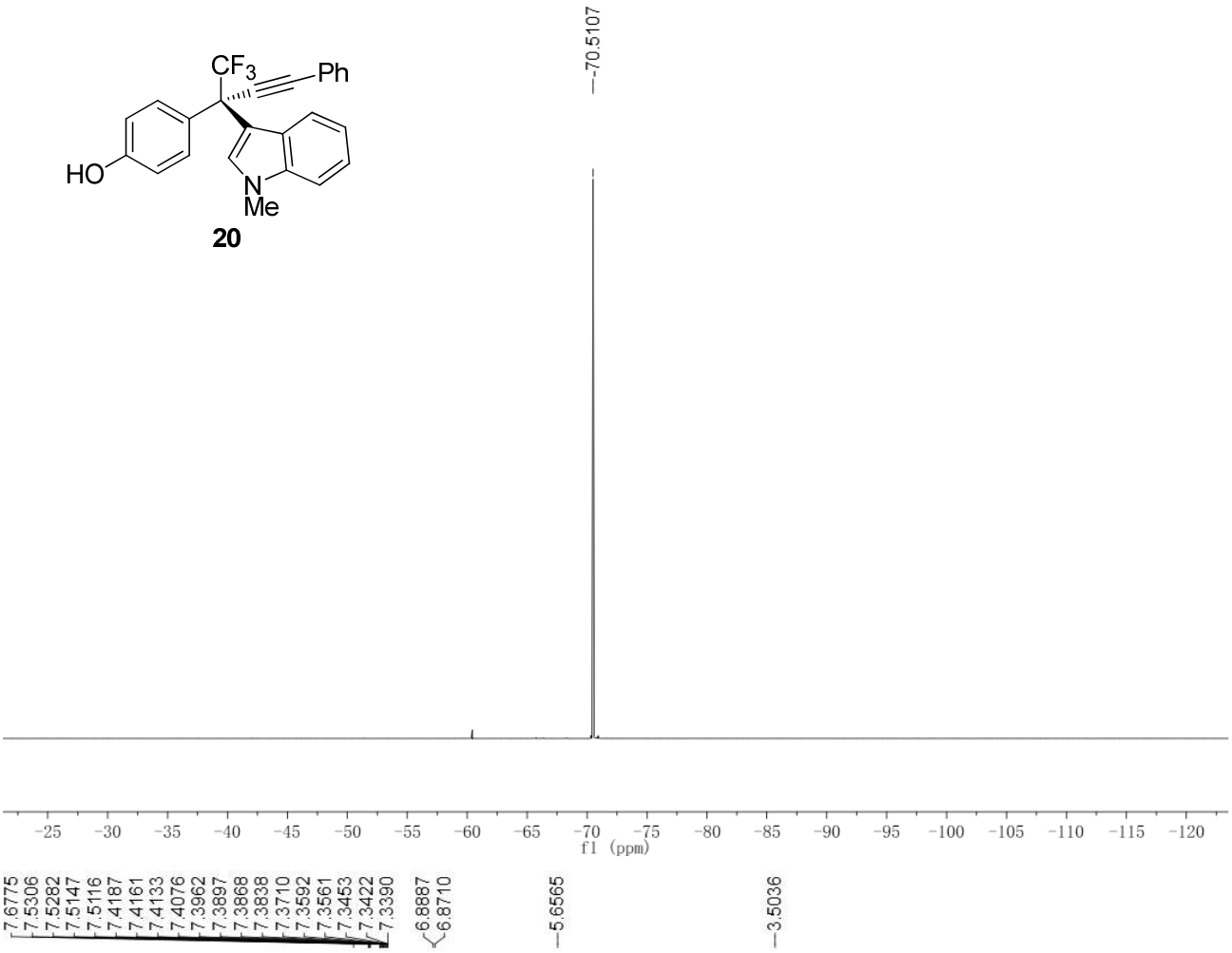
Me
20
f1 (ppm)

CF3
Ph
HO
N
Me

20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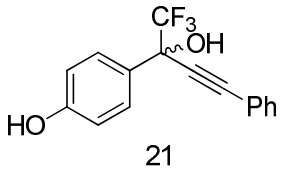
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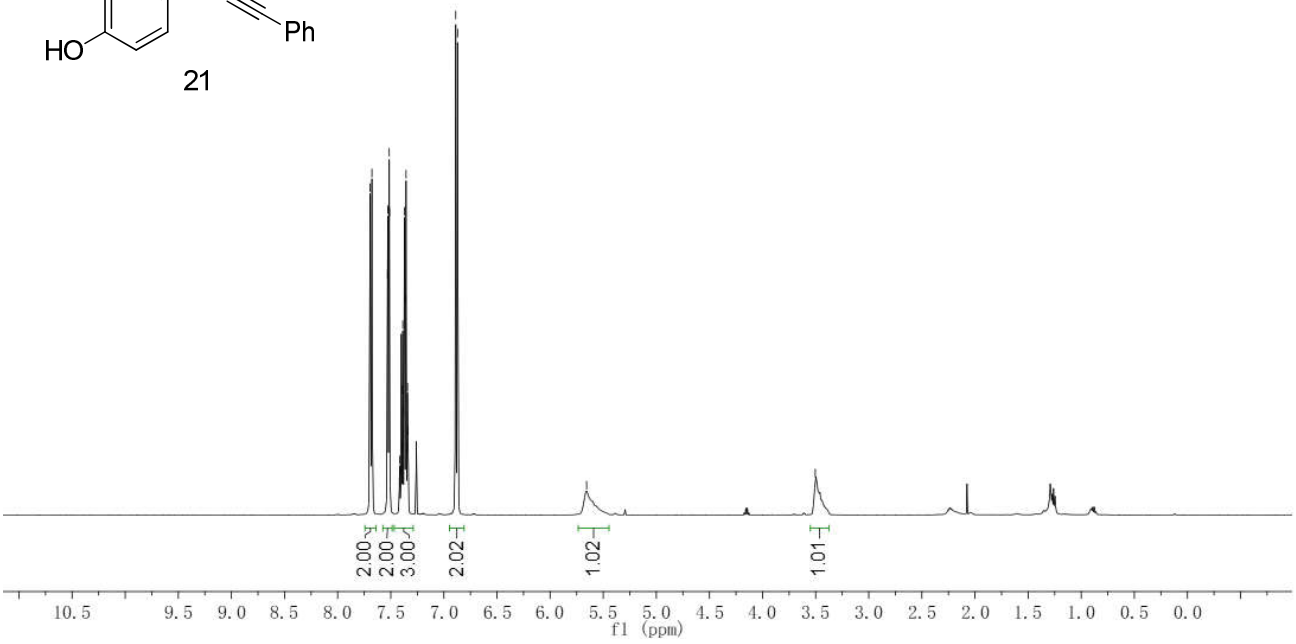
OH
HO
Ph

21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1.01
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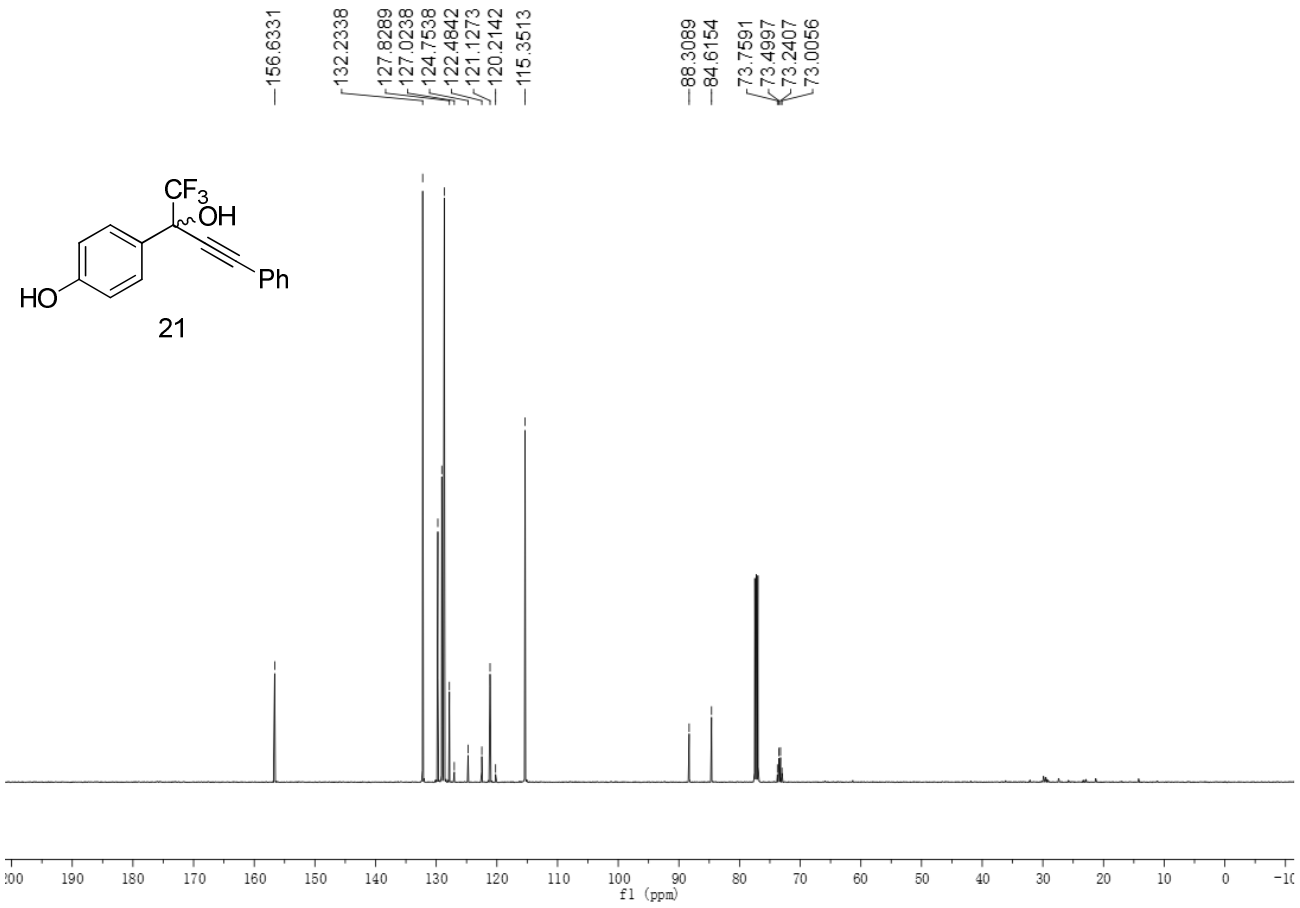
f1 (ppm)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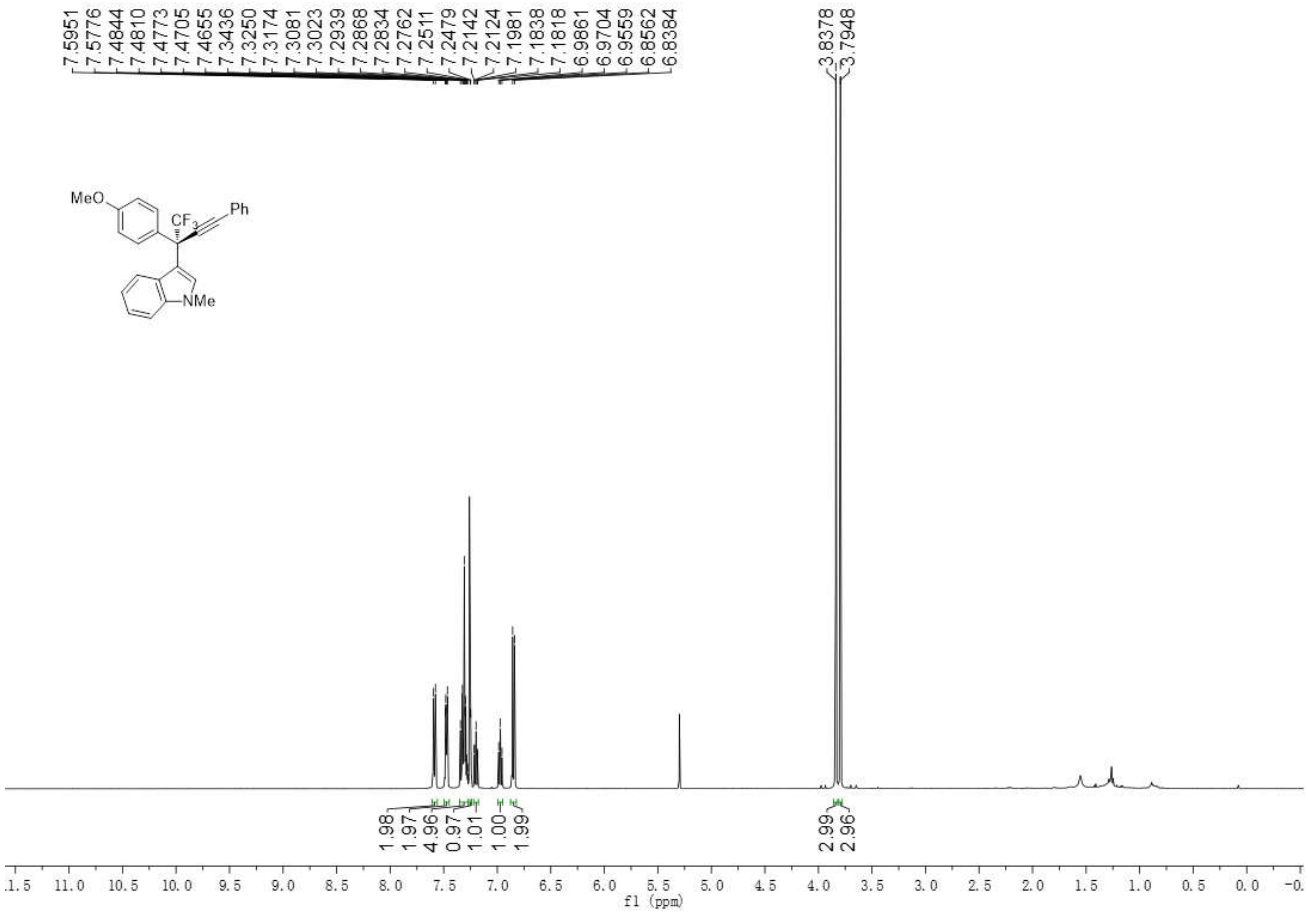
CF3
OH
HO
Ph
21
f1 (ppm)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7.1818
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6.8562
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CF3
Ph
NMe
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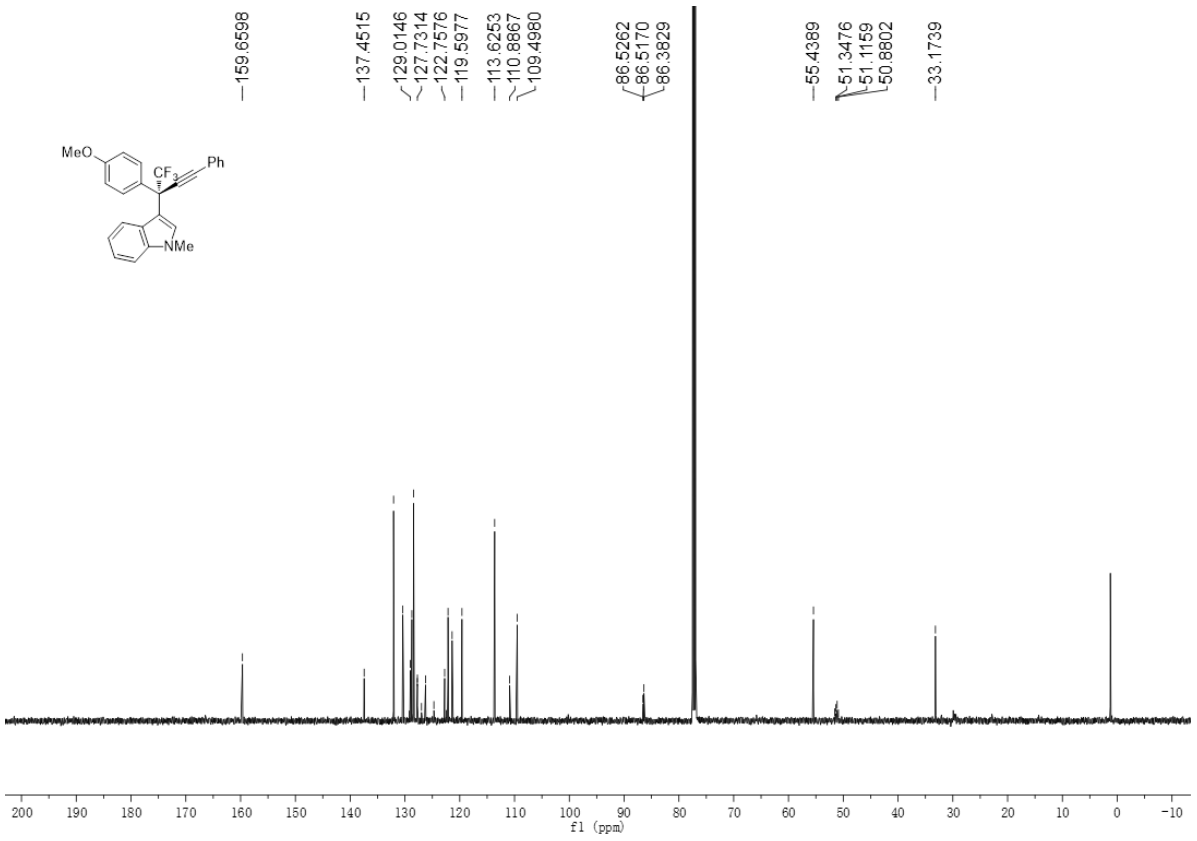
1.99
2.99
2.96
f1 (ppm)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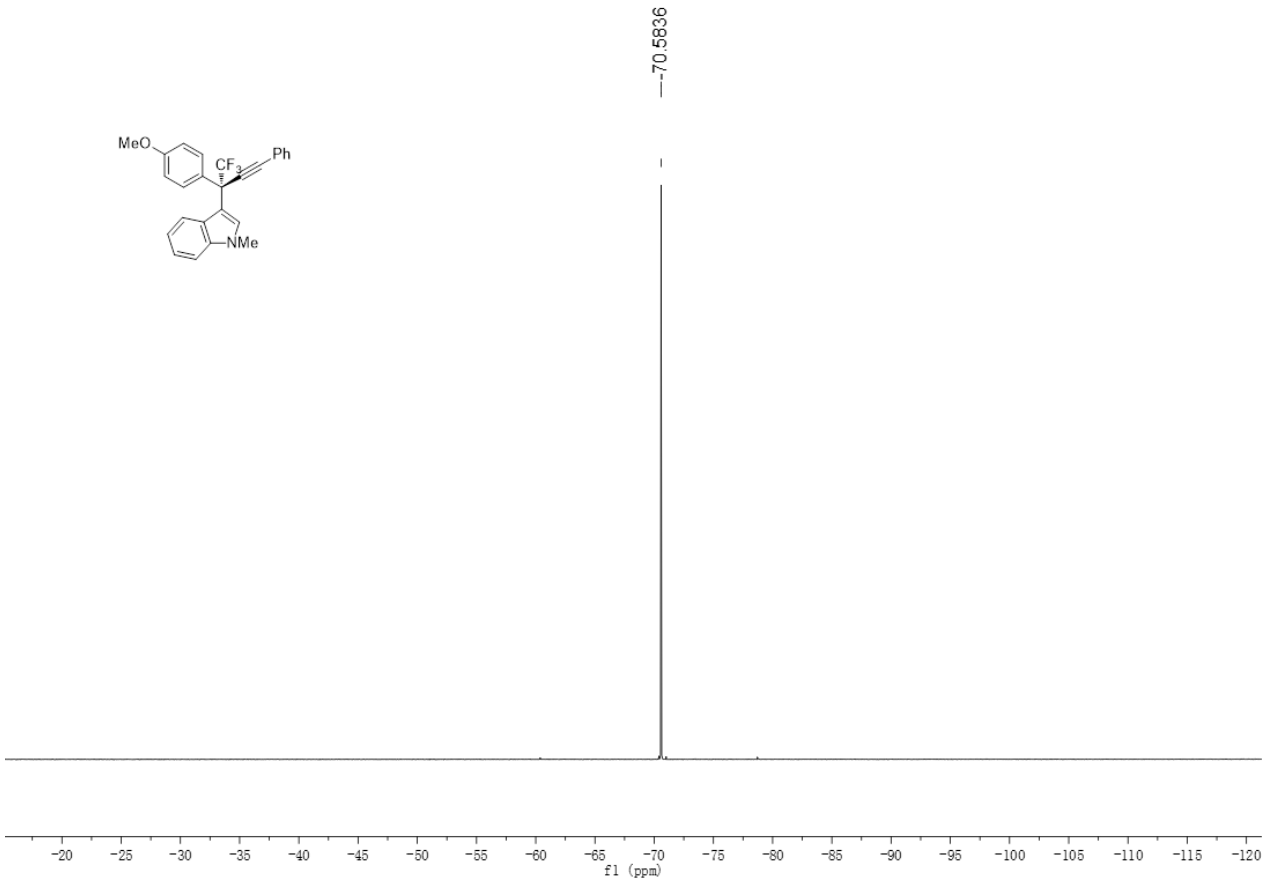
Ph
NMe
f1 (ppm)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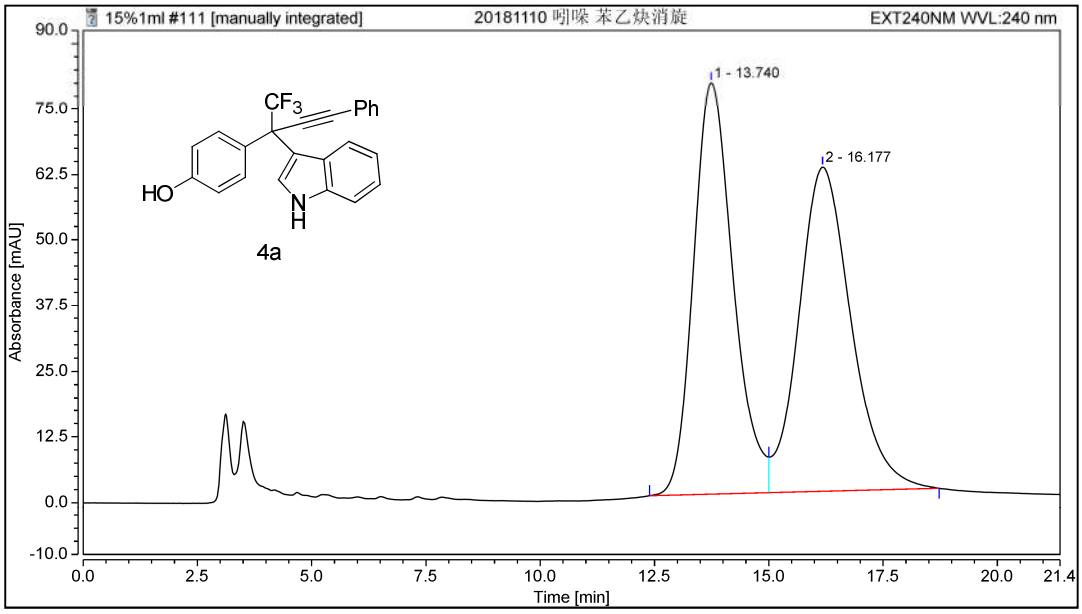
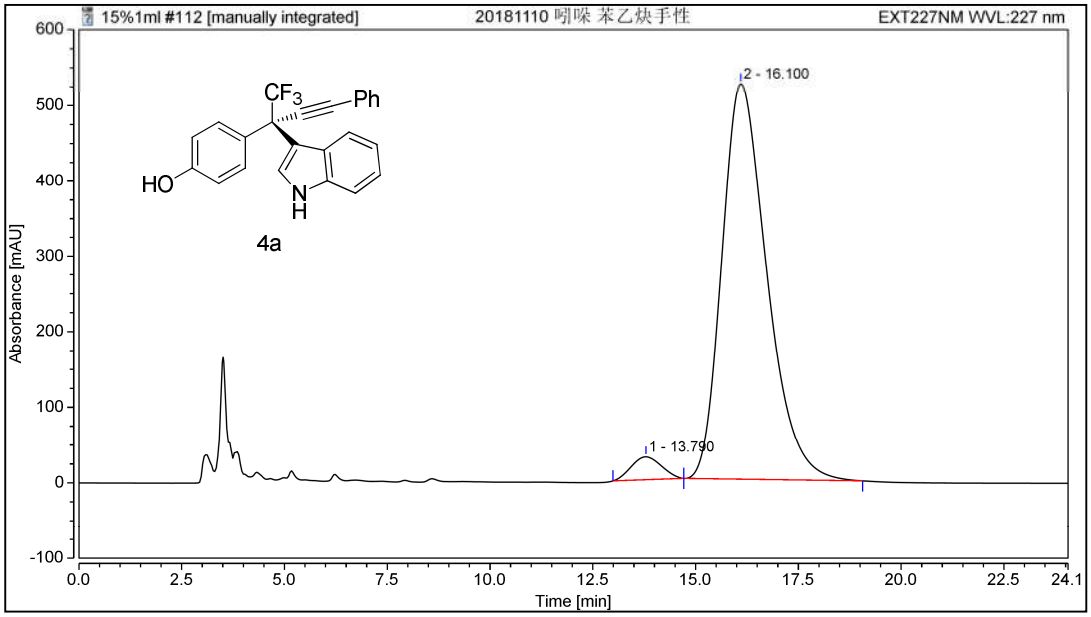
NMe
f1 (ppm)

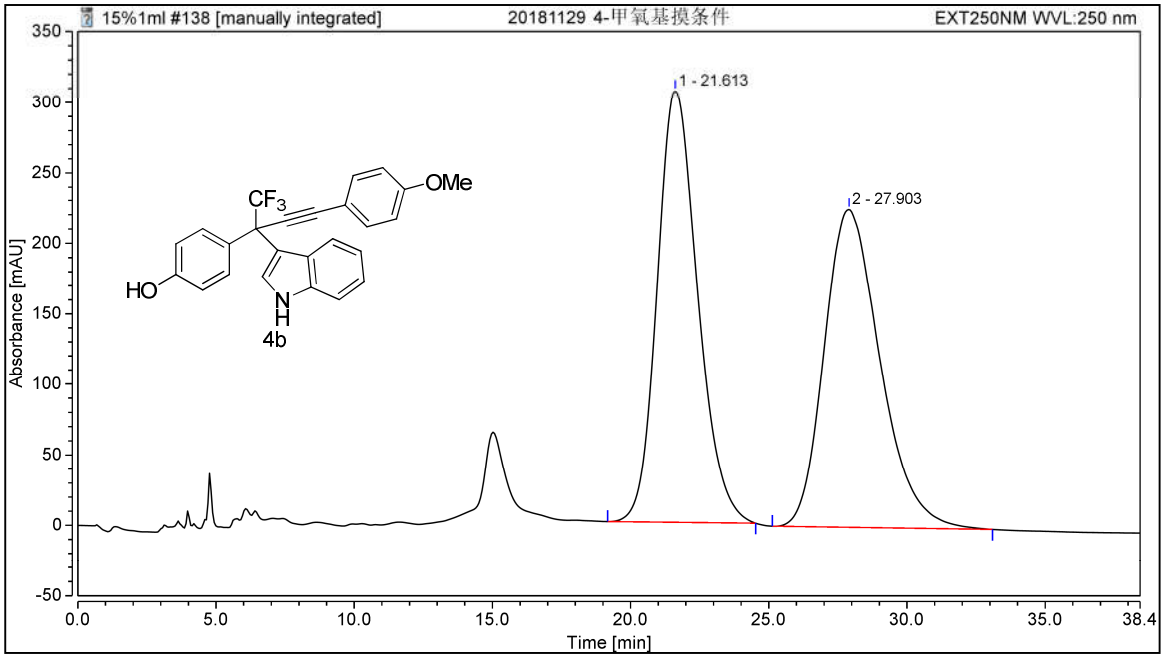
HPLC spectra for ee determination



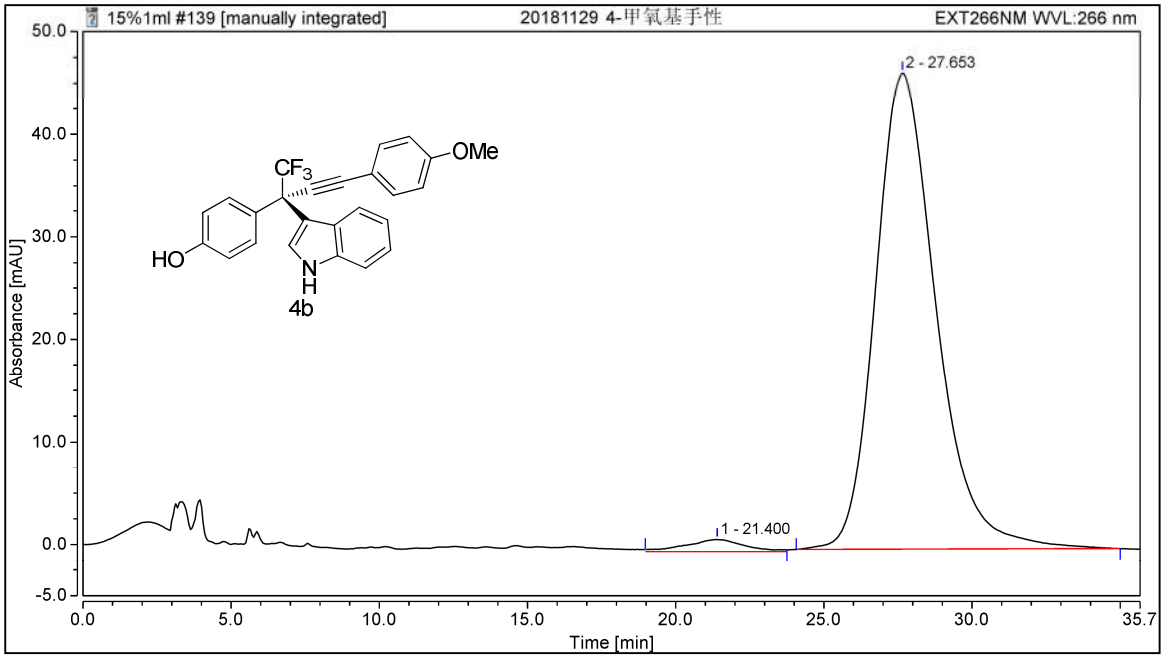
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.740	78.782	49.04	n.a.
2		16.177	81.864	50.96	n.a.
Total:			**160.646**	**100.00**	



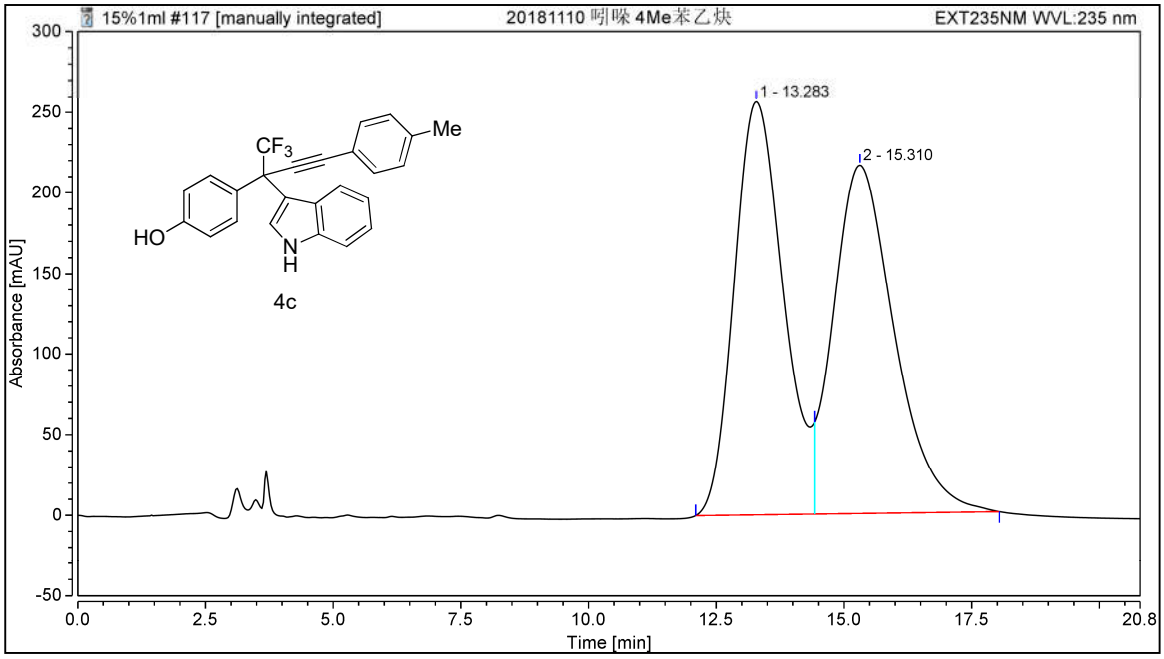
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.790	25.534	3.71	n.a.
2		16.100	662.918	96.29	n.a.
Total:			**688.452**	**100.00**	



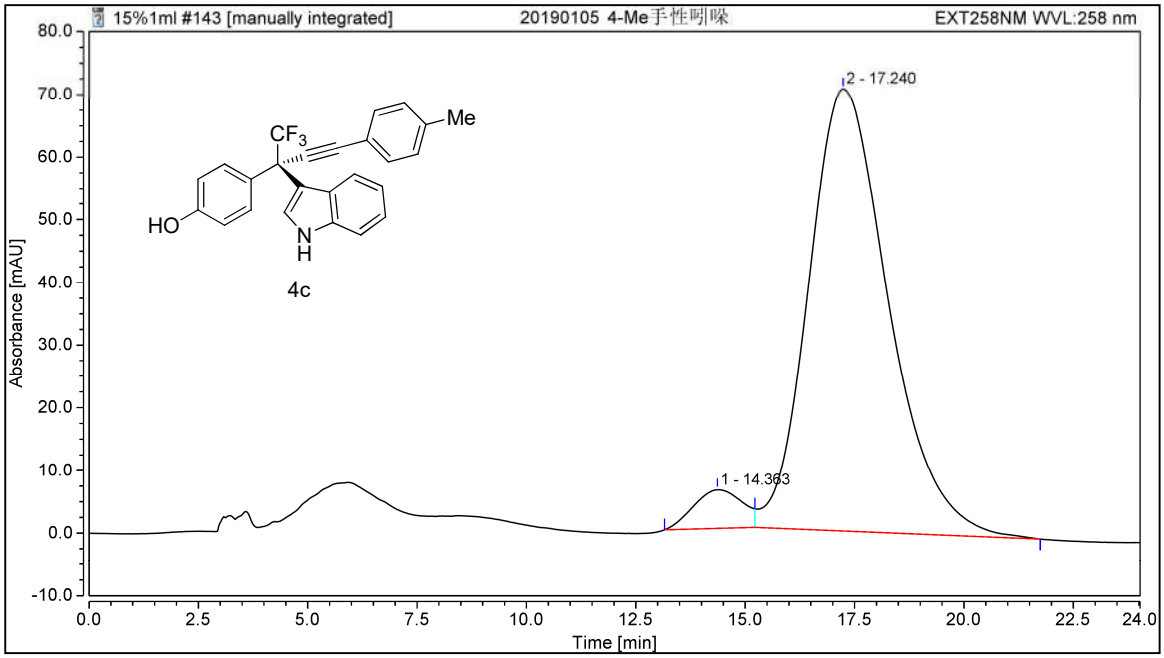
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		21.613	519.701	49.63	n.a.
2		27.903	527.413	50.37	n.a.
Total:			**1047.114**	**100.00**	



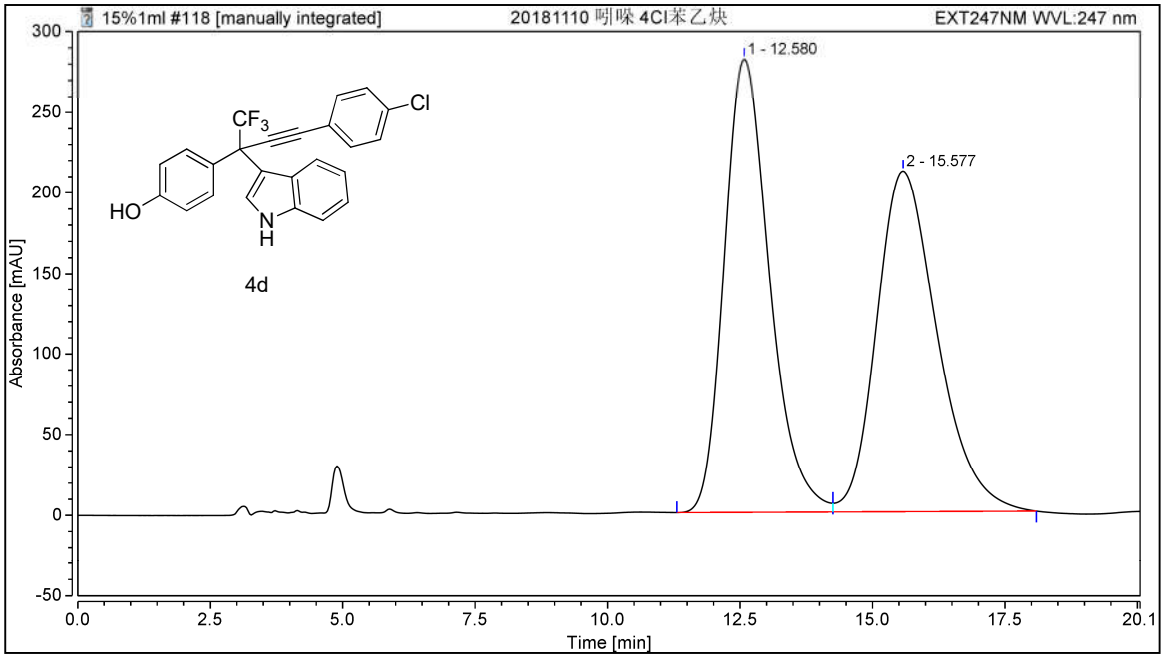
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		21.400	2.749	2.44	n.a.
2		27.653	109.940	97.56	n.a.
Total:			**112.689**	**100.00**	



Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.283	286.196	48.99	n.a.
2		15.310	298.009	51.01	n.a.
Total:			**584.204**	**100.00**	

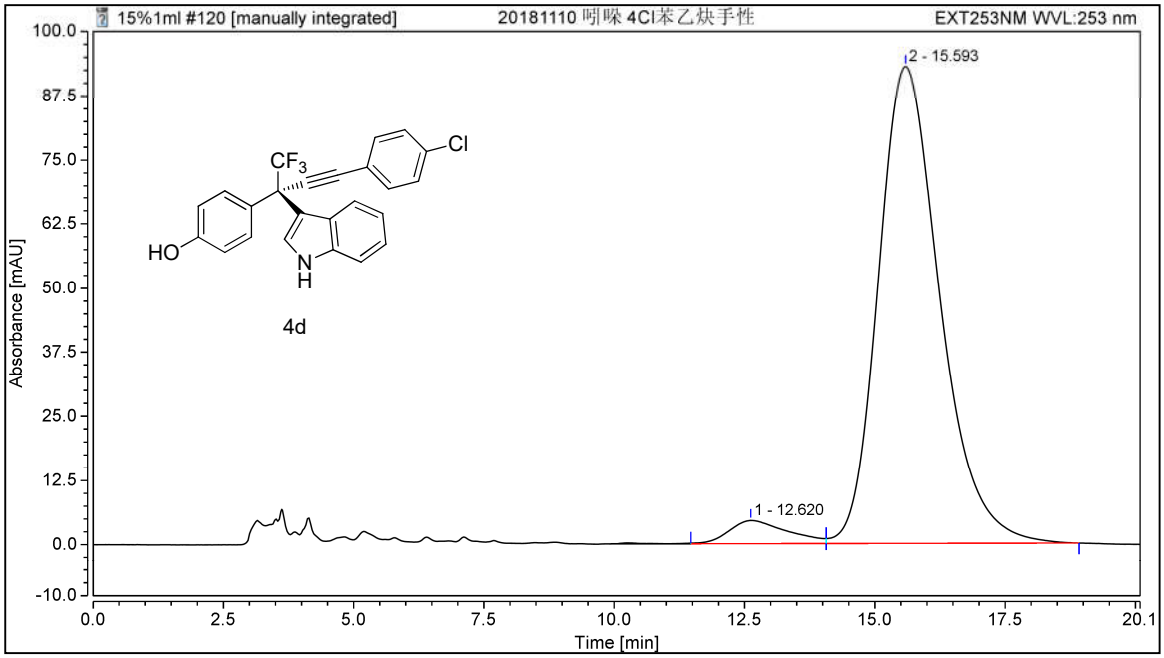


Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		14.363	7.928	5.04	n.a.
2		17.240	149.396	94.96	n.a.
Total:			**157.324**	**100.00**	



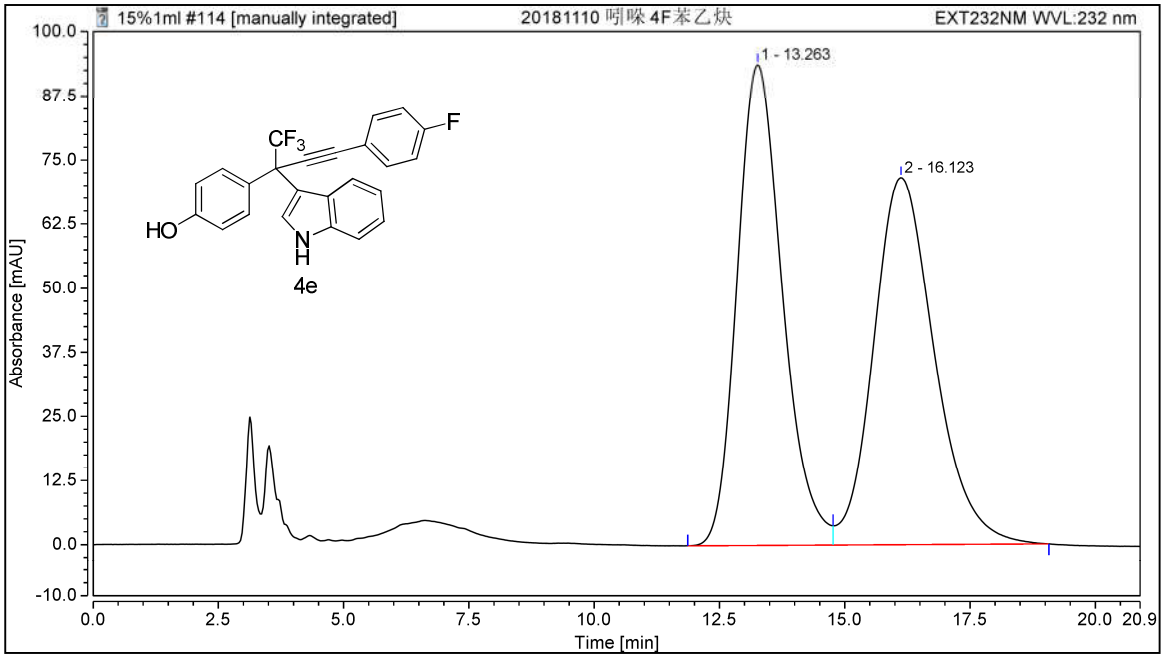
Integration Results

No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		12.580	278.634	49.94	n.a.
2		15.577	279.358	50.06	n.a.
Total:			**557.993**	**100.00**	



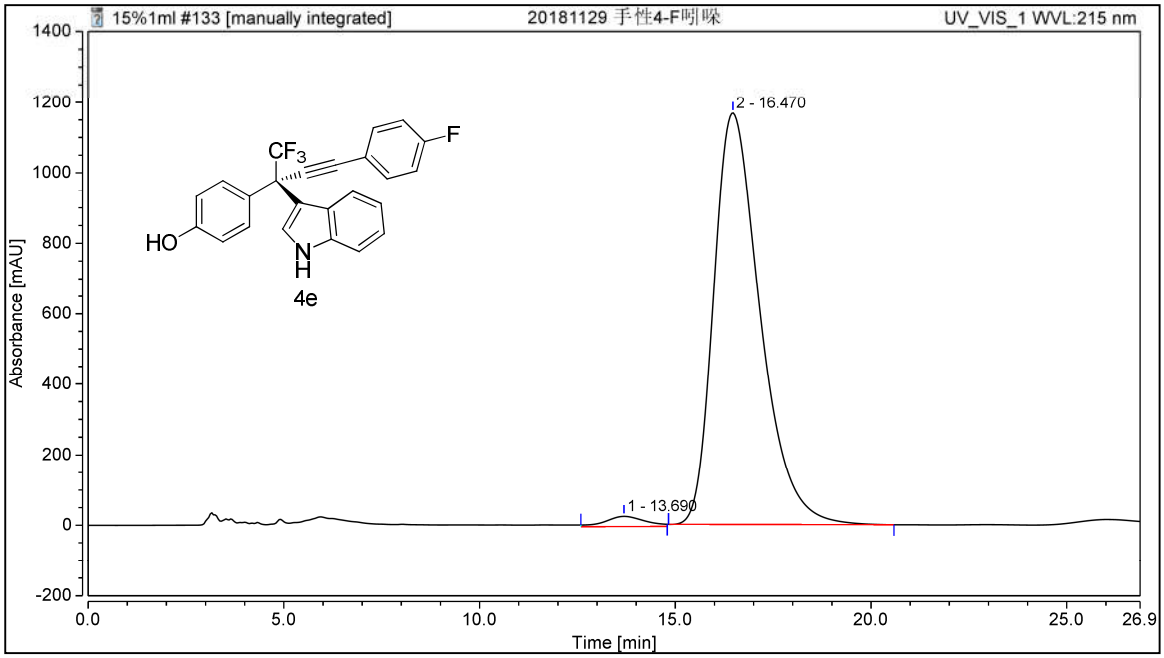
Integration Results

No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		12.620	5.829	4.39	n.a.
2		15.593	127.027	95.61	n.a.
Total:			**132.856**	**100.00**	



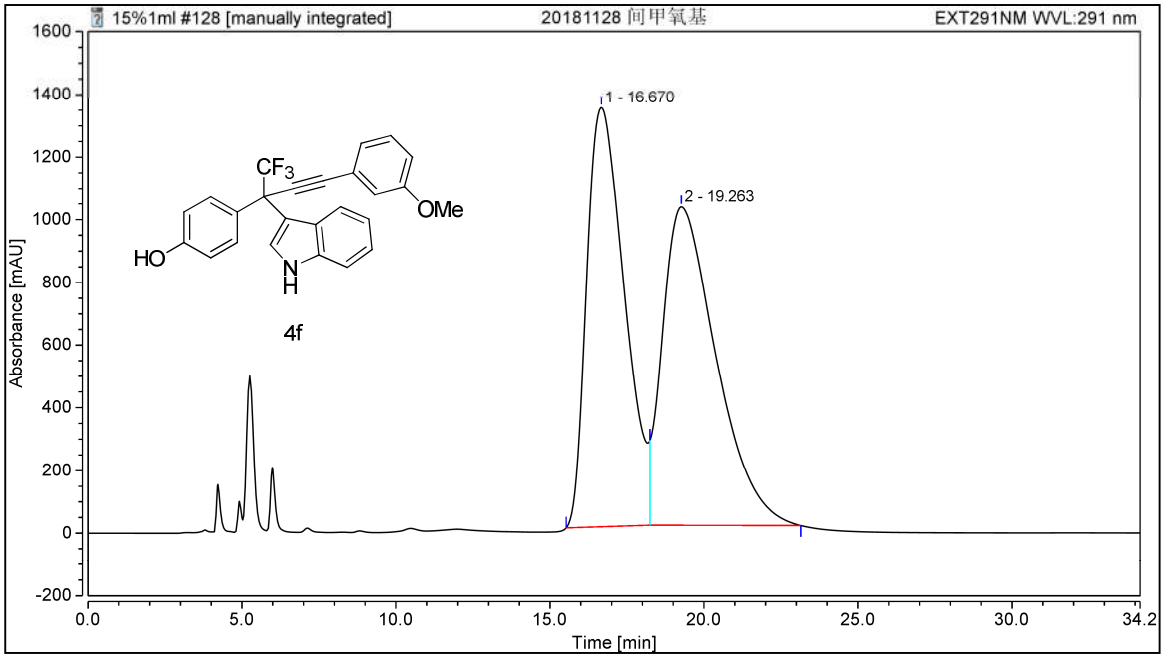
Integration Results

No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.263	98.168	49.43	n.a.
2		16.123	100.422	50.57	n.a.
Total:			**198.589**	**100.00**	

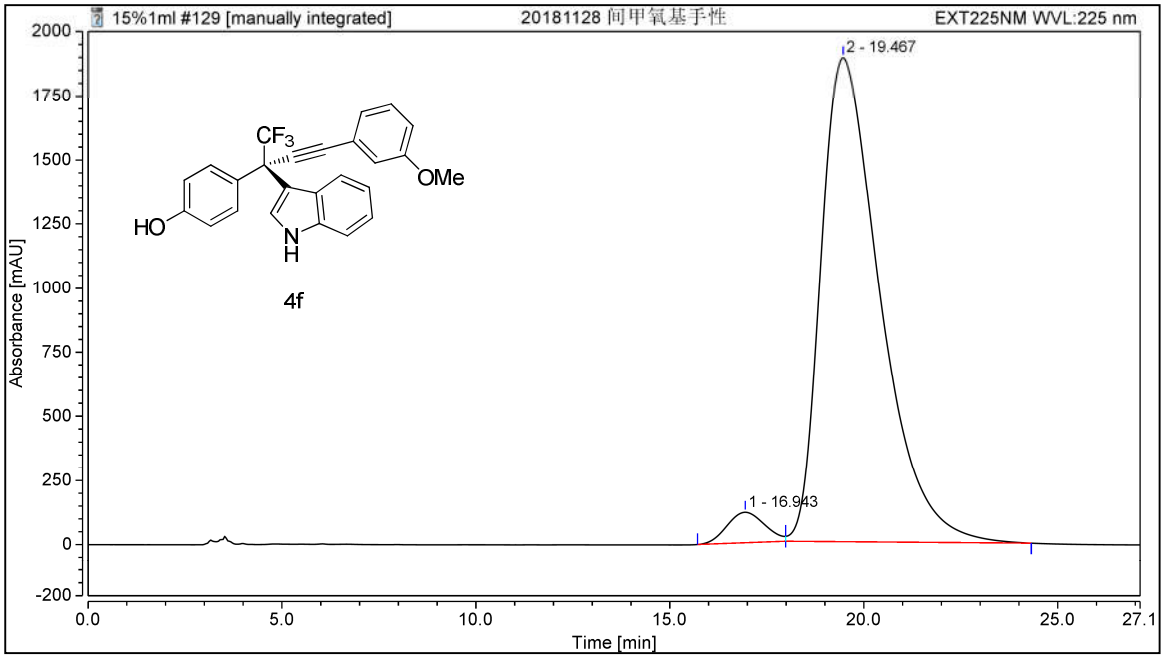


Integration Results

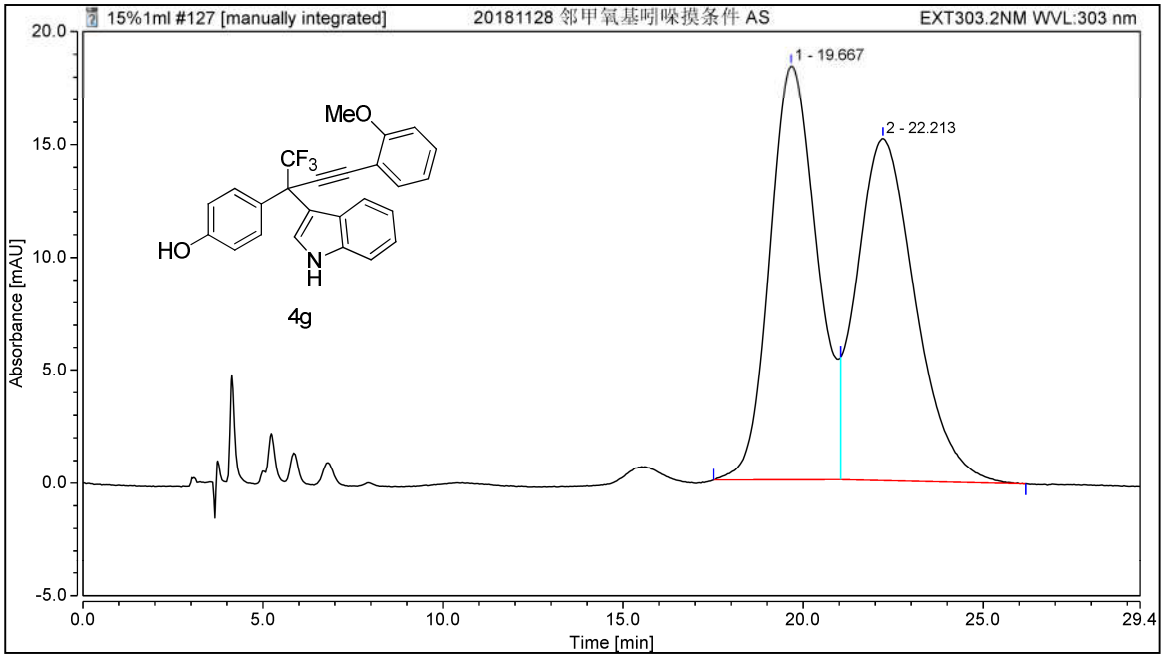
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.690	34.242	2.09	n.a.
2		16.470	1604.920	97.91	n.a.
Total:			**1639.162**	**100.00**	



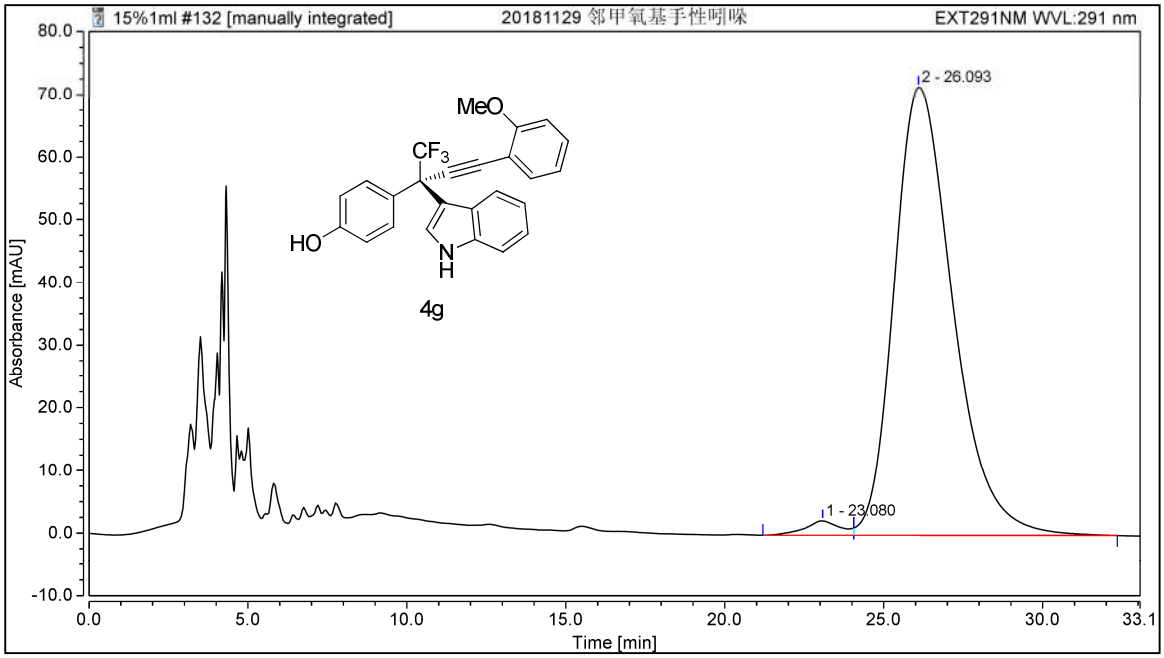
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		16.670	1901.324	48.13	n.a.
2		19.263	2049.436	51.87	n.a.
Total:			**3950.760**	**100.00**	



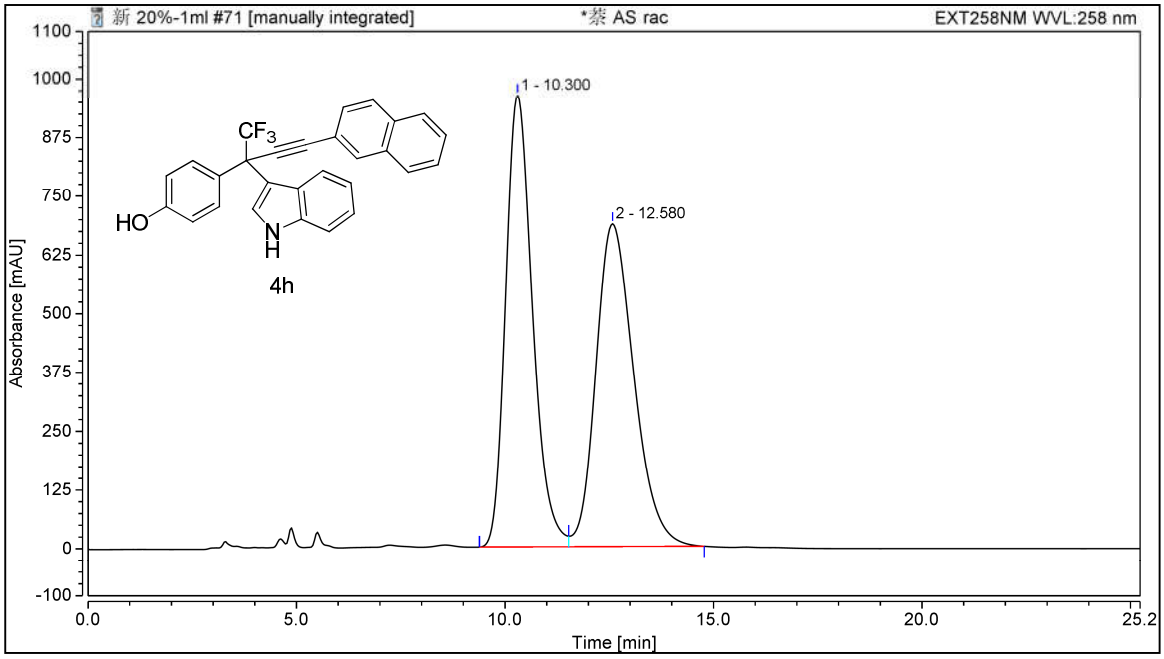
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		16.943	133.471	3.85	n.a.
2		19.467	3329.168	96.15	n.a.
Total:			**3462.639**	**100.00**	



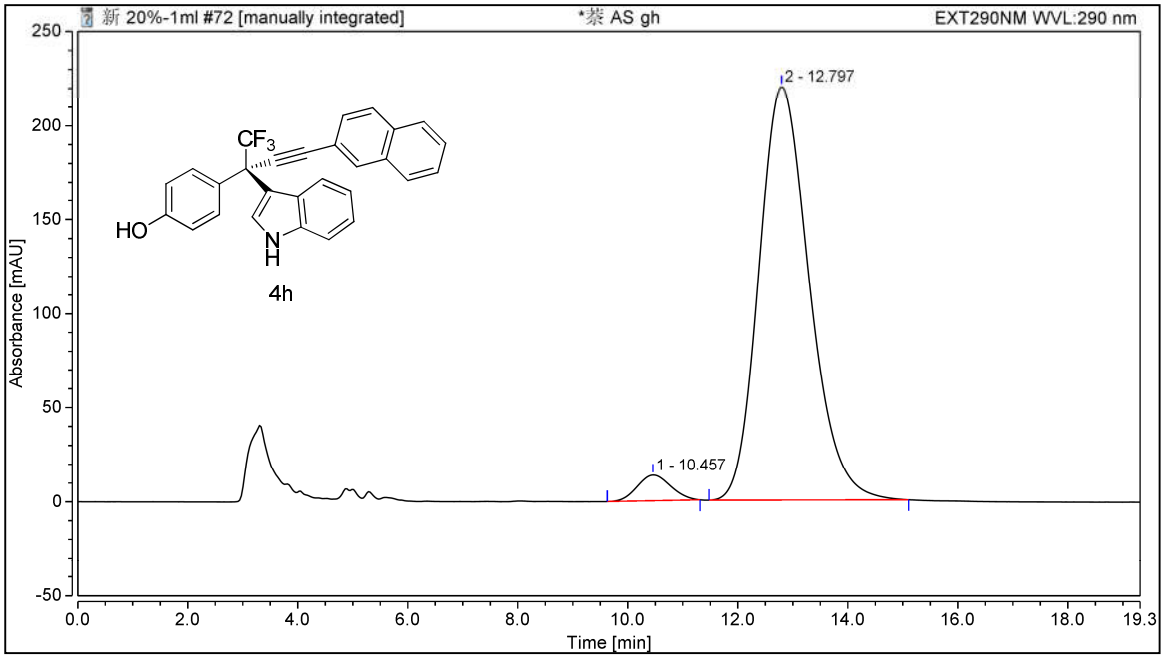
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		19.667	27.908	49.39	n.a.
2		22.213	28.595	50.61	n.a.
Total:			**56.503**	**100.00**	



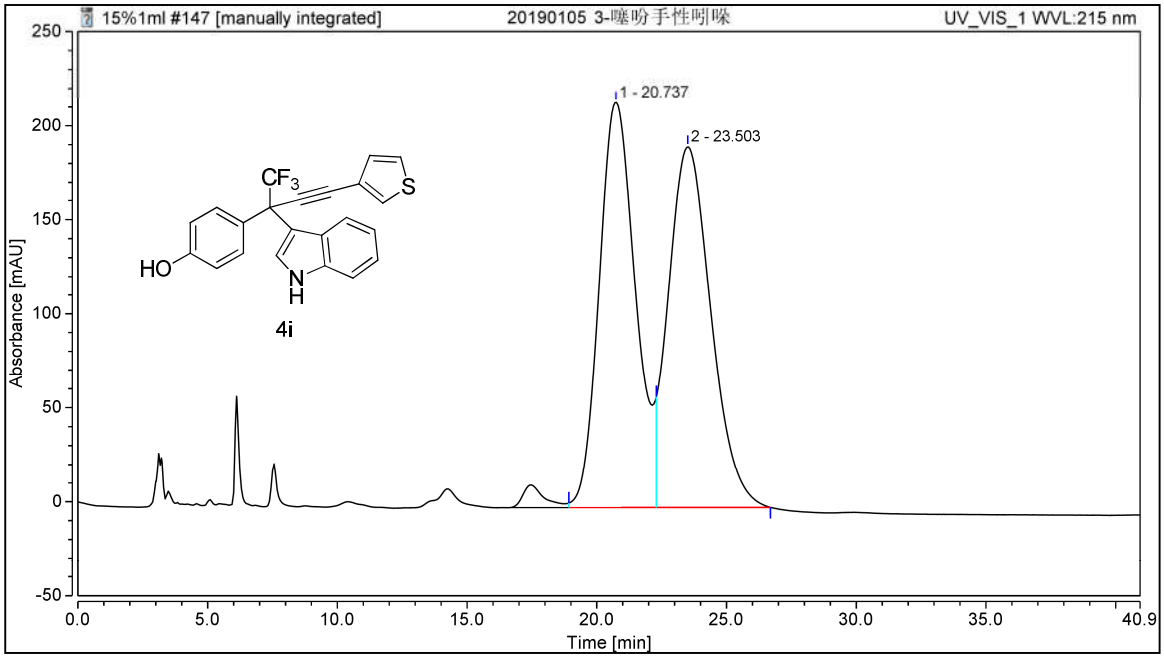
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		23.080	2.958	1.90	n.a.
2		26.093	153.050	98.10	n.a.
Total:			**156.008**	**100.00**	



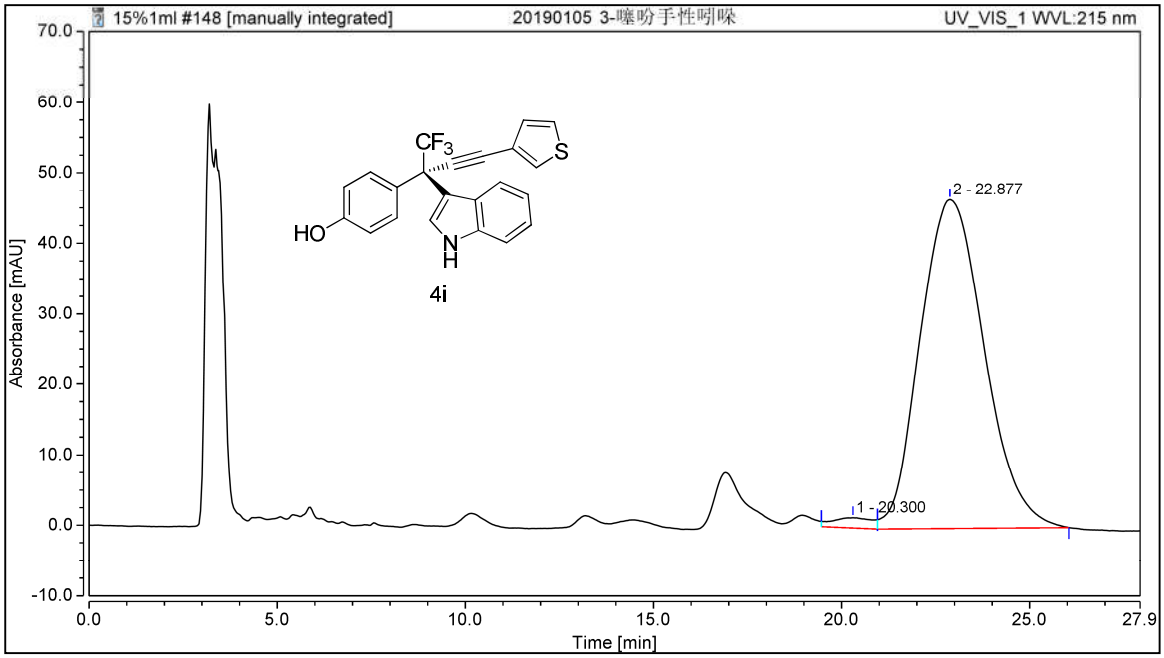
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		10.300	717.035	49.76	n.a.
2		12.580	723.885	50.24	n.a.
Total:			**1440.920**	**100.00**	



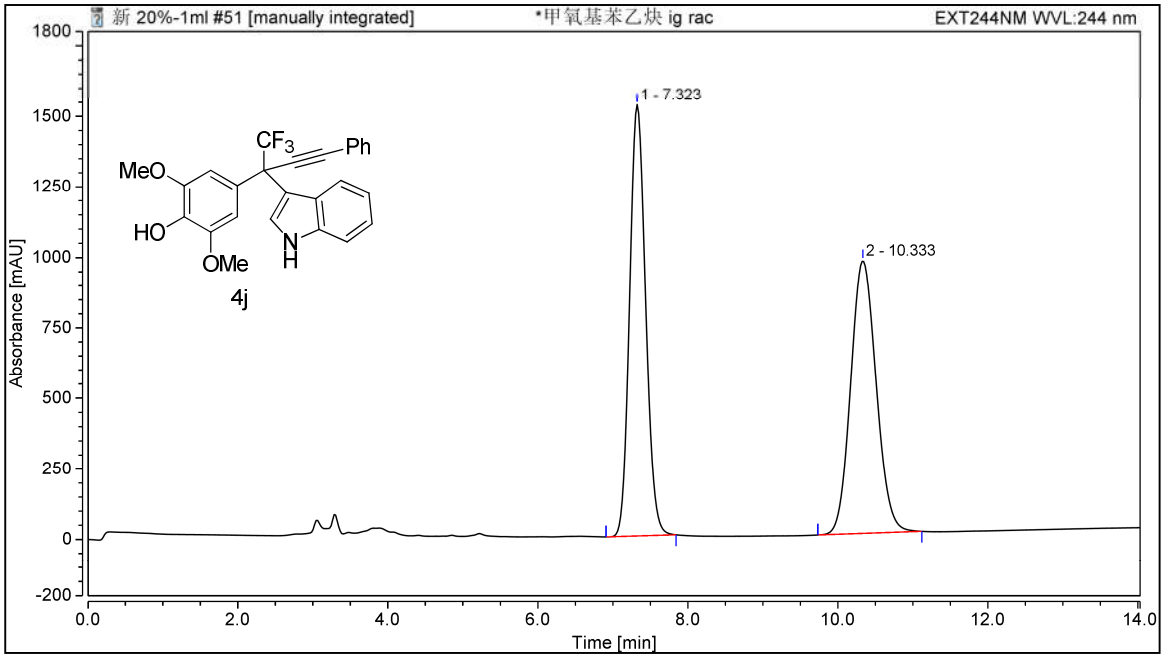
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		10.457	9.626	3.97	n.a.
2		12.797	233.079	96.03	n.a.
Total:			**242.705**	**100.00**	



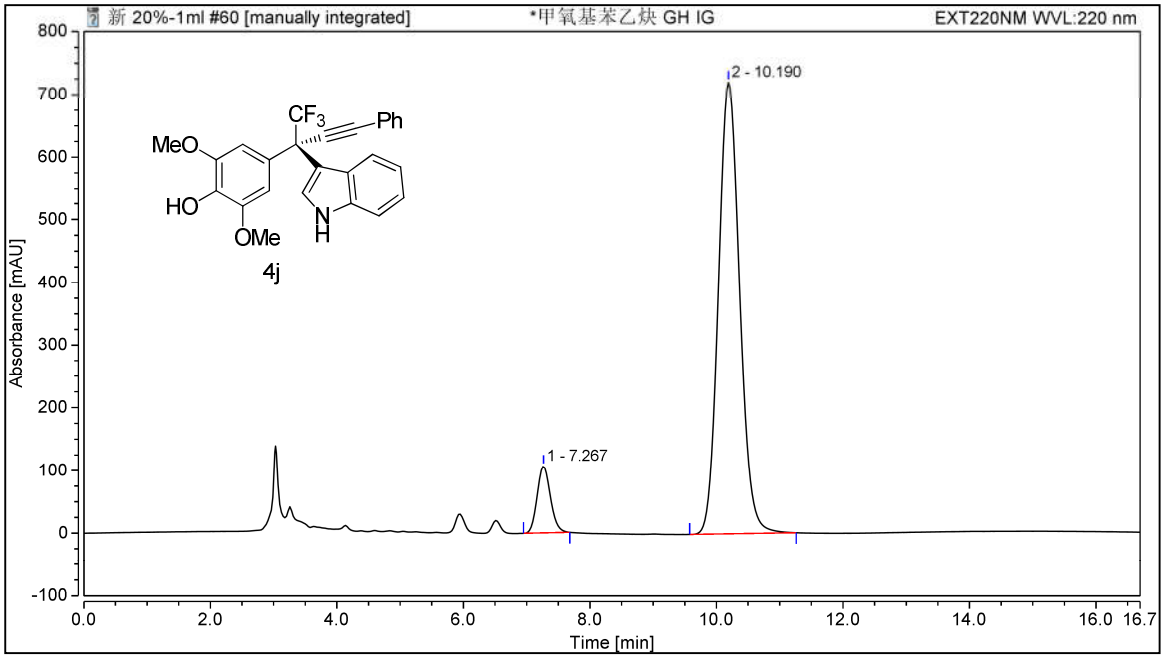
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		20.737	348.887	49.03	n.a.
2		23.503	362.676	50.97	n.a.
Total:			**711.563**	**100.00**	



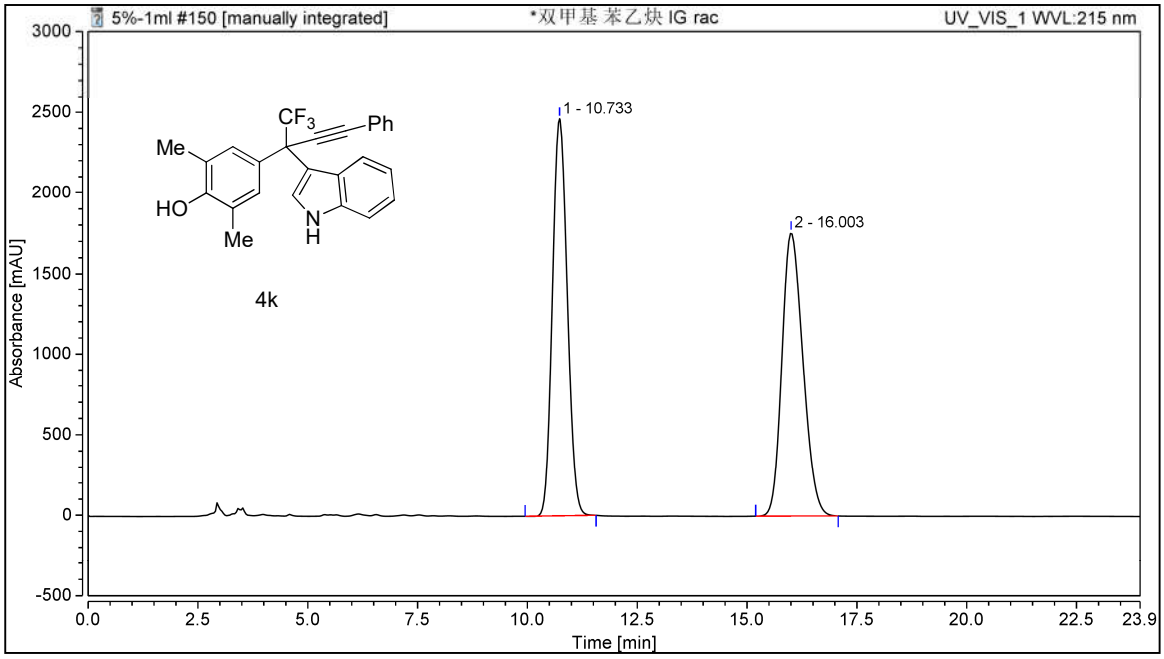
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		20.300	1.791	1.91	n.a.
2		22.877	92.179	98.09	n.a.
Total:			**93.969**	**100.00**	



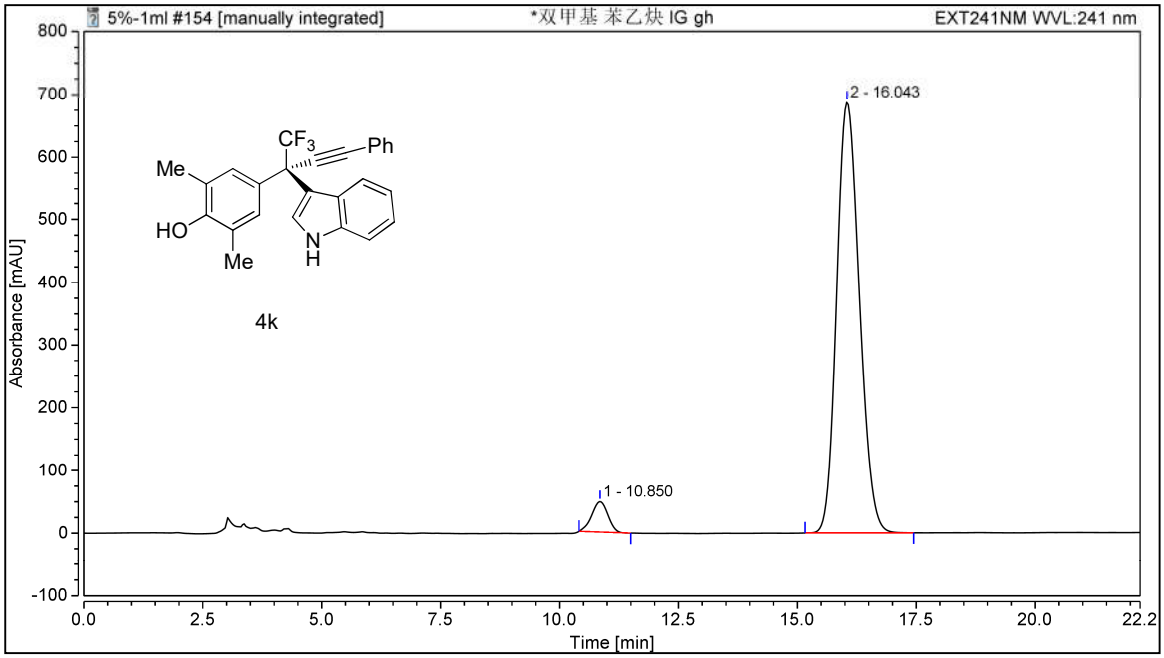
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.323	377.472	49.78	n.a.
2		10.333	380.820	50.22	n.a.
Total:			**758.292**	**100.00**	



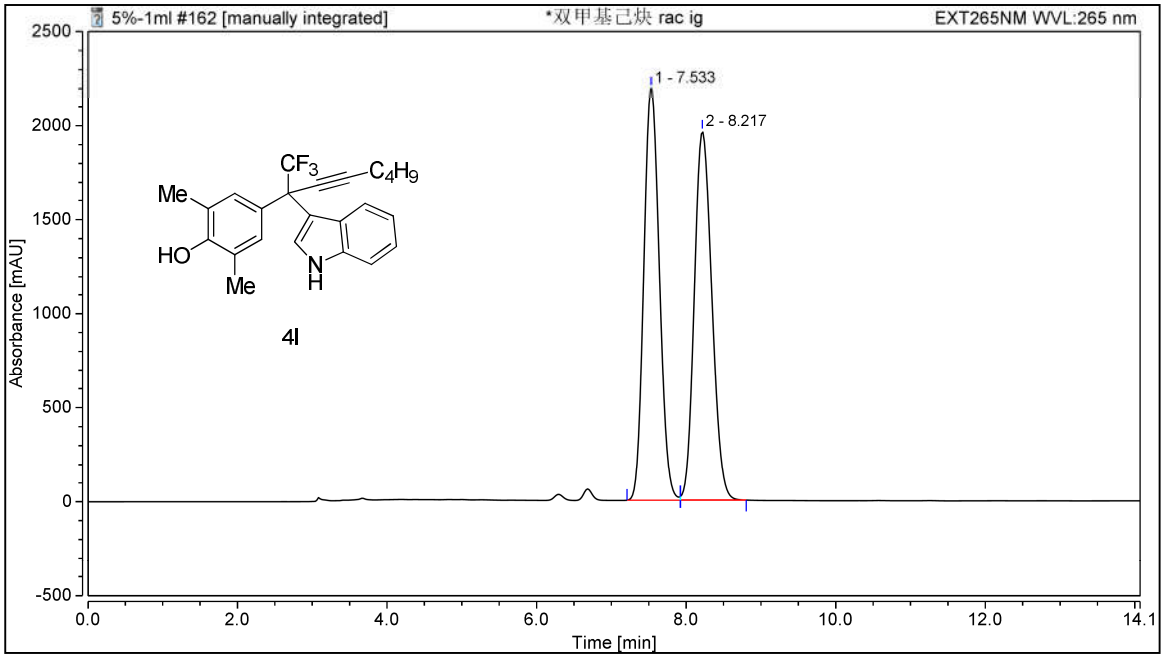
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.267	25.886	8.48	n.a.
2		10.190	279.245	91.52	n.a.
Total:			**305.131**	**100.00**	



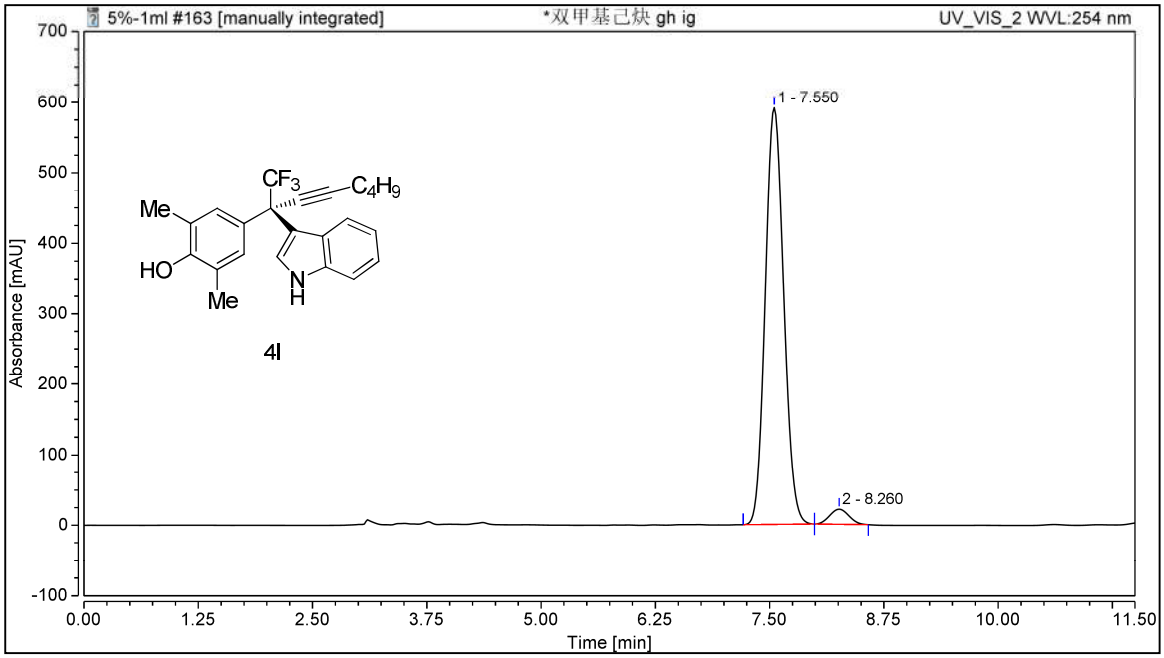
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		10.733	964.219	49.75	n.a.
2		16.003	973.902	50.25	n.a.
Total:			**1938.121**	**100.00**	



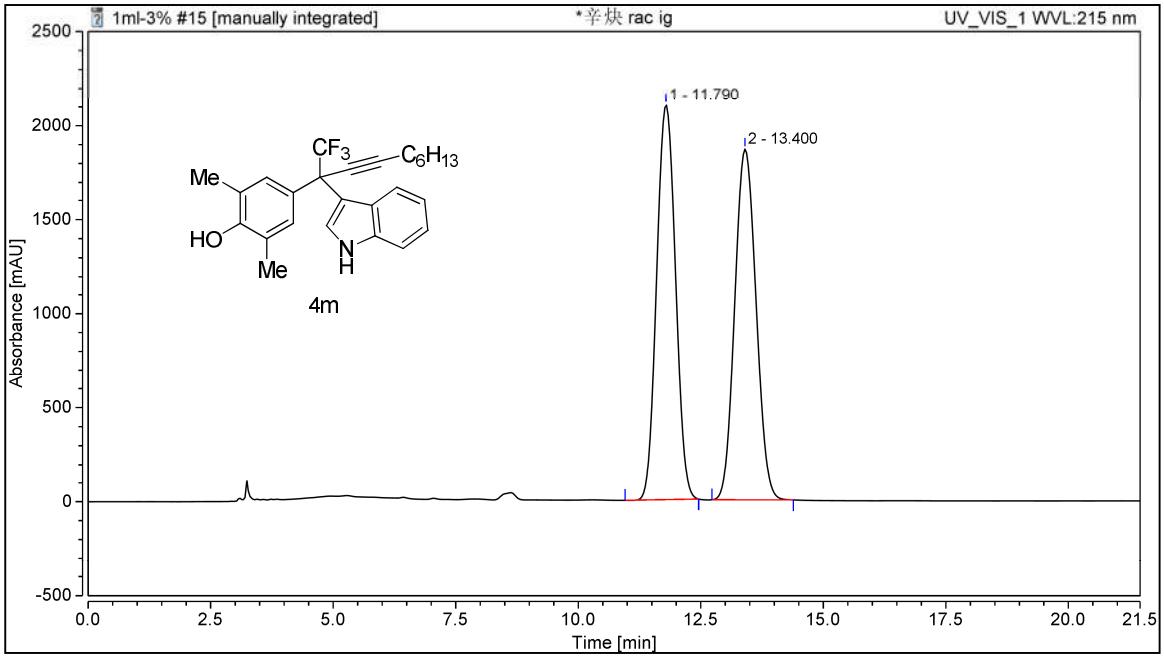
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		10.850	19.031	4.76	n.a.
2		16.043	380.653	95.24	n.a.
Total:			**399.684**	**100.00**	



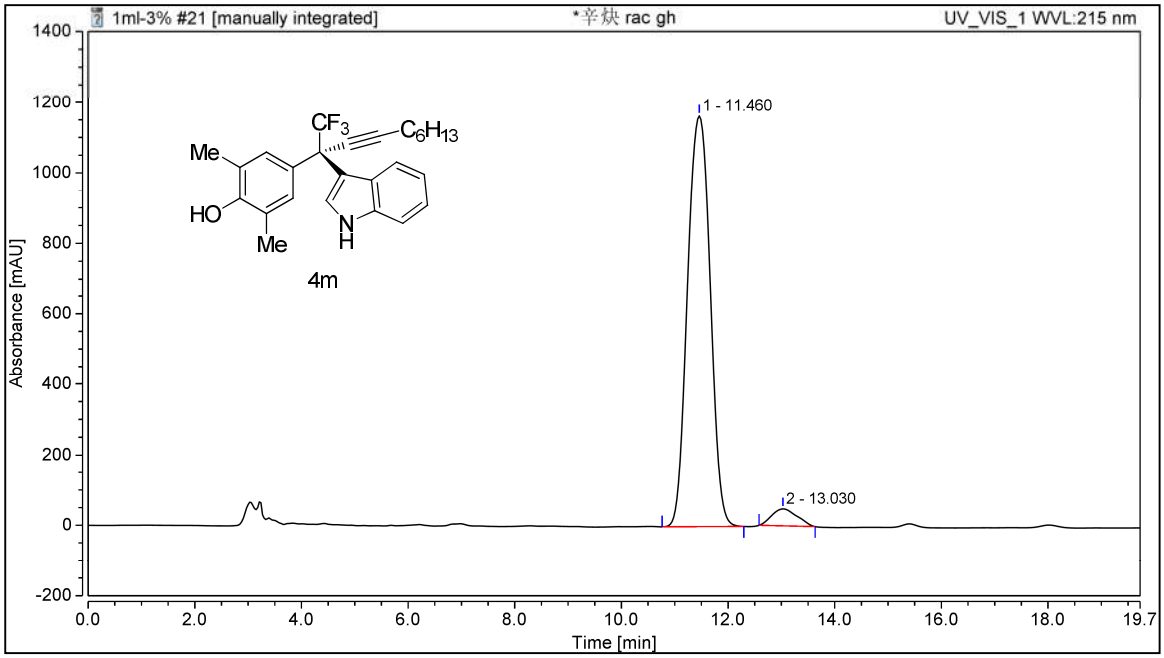
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.533	529.244	49.84	n.a.
2		8.217	532.691	50.16	n.a.
Total:			**1061.935**	**100.00**	



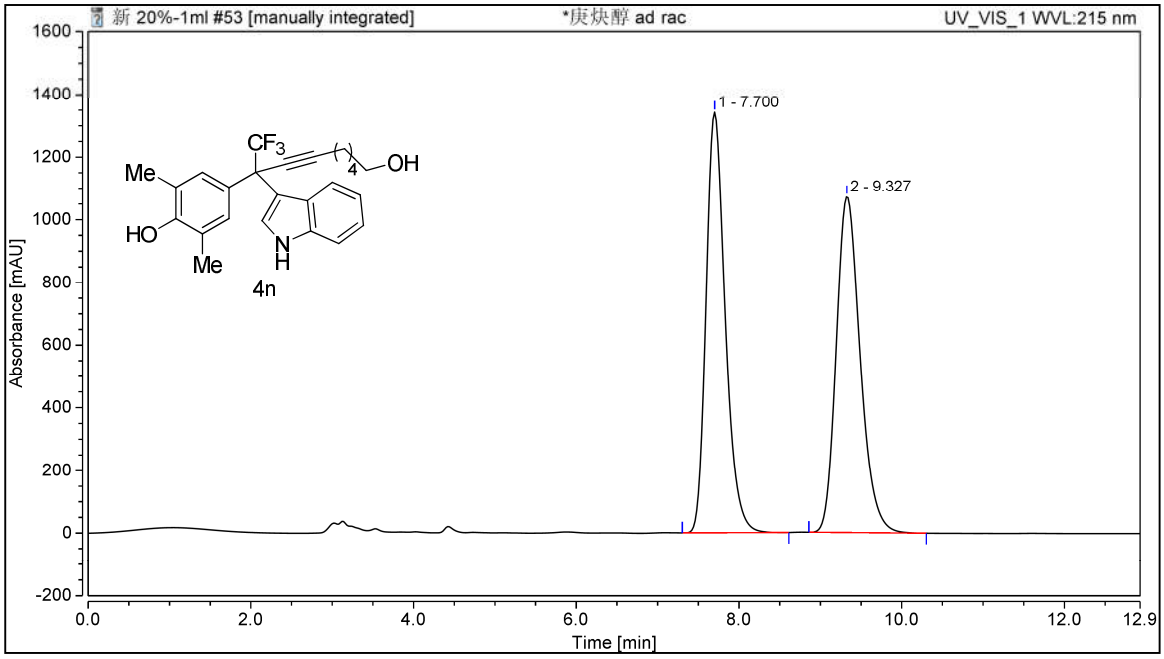
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.550	138.246	96.35	n.a.
2		8.260	5.232	3.65	n.a.
Total:			**143.478**	**100.00**	



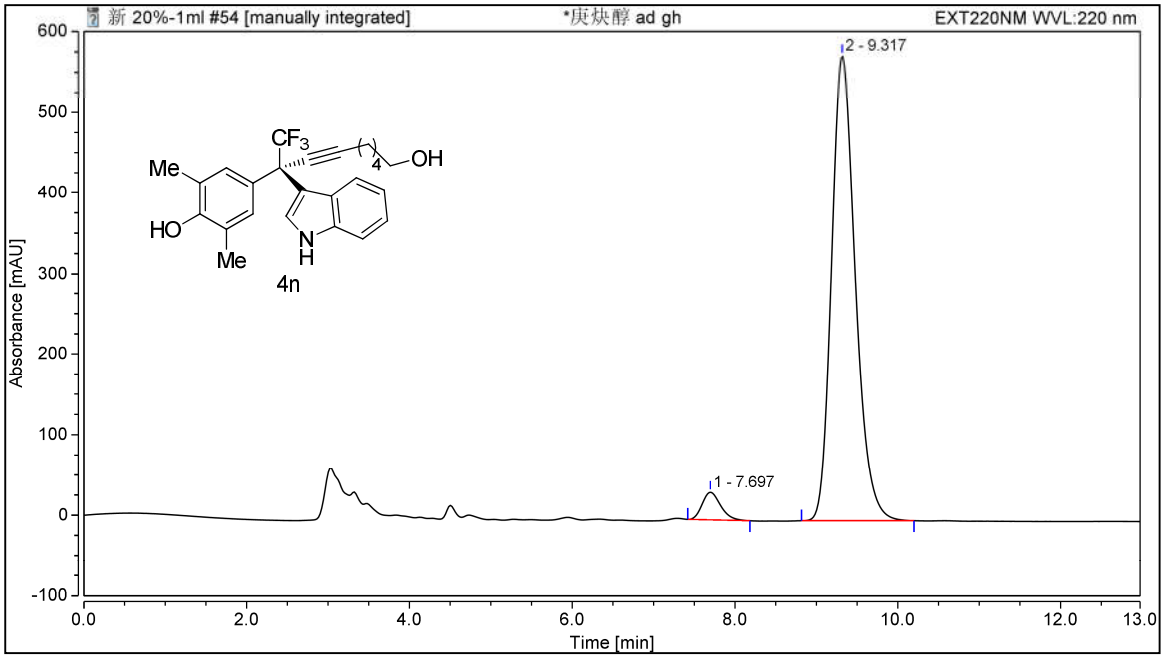
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		11.790	936.221	49.93	n.a.
2		13.400	938.747	50.07	n.a.
Total:			**1874.968**	**100.00**	



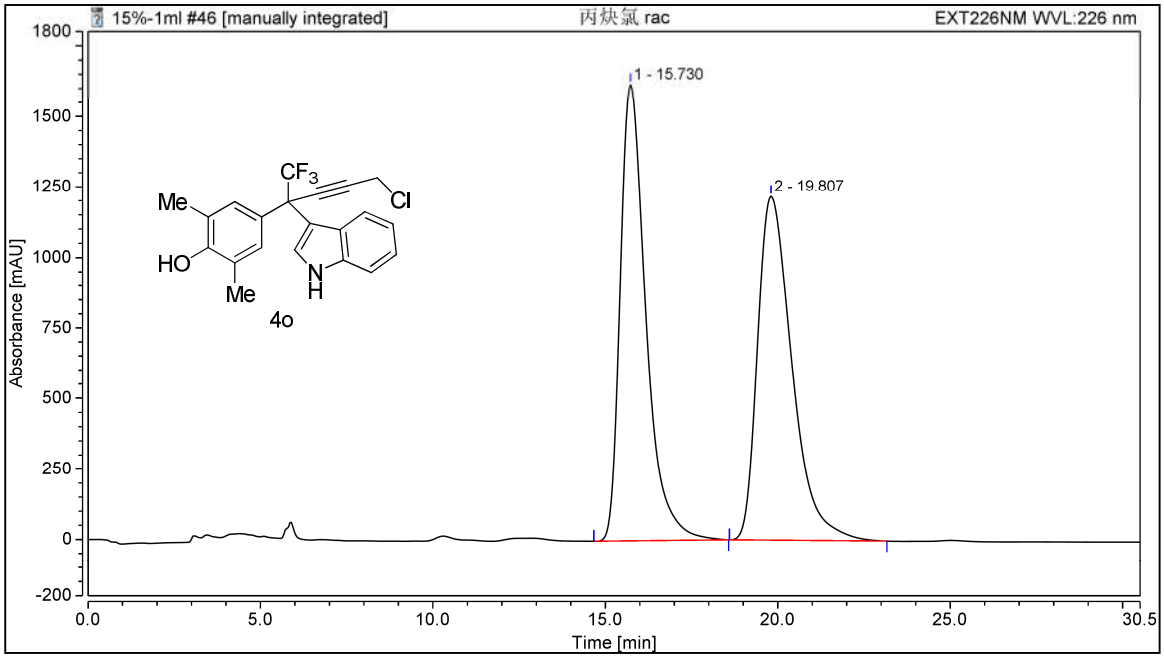
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		11.460	574.595	95.62	n.a.
2		13.030	26.346	4.38	n.a.
Total:			**600.941**	**100.00**	



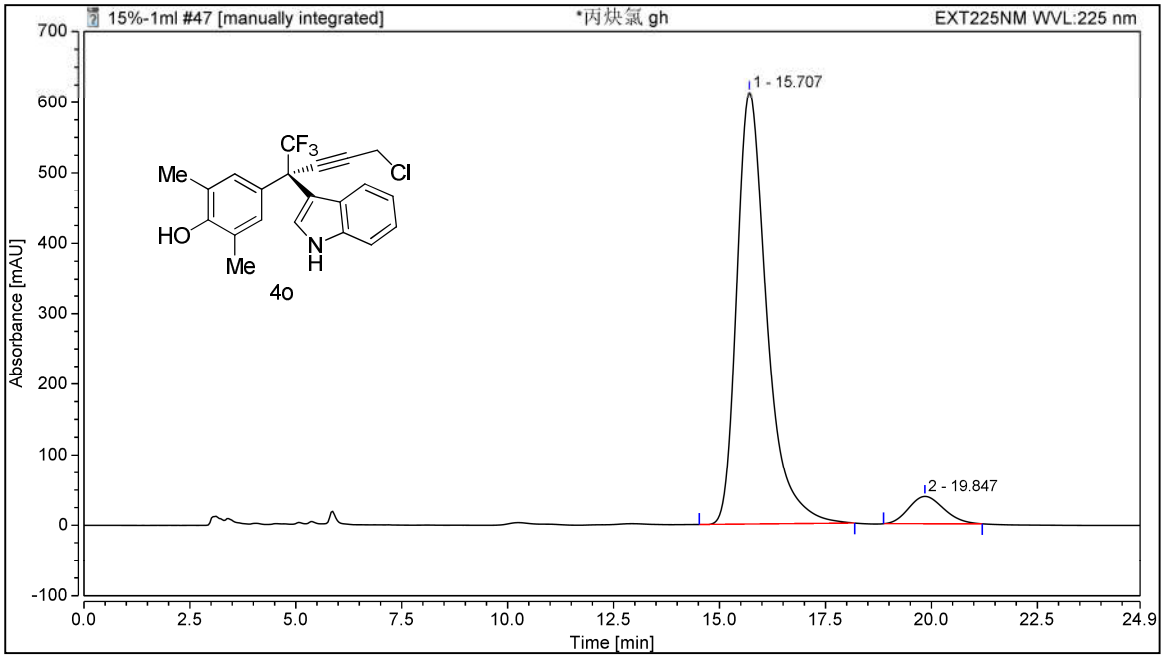
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.700	365.330	50.02	n.a.
2		9.327	365.062	49.98	n.a.
Total:			**730.392**	**100.00**	



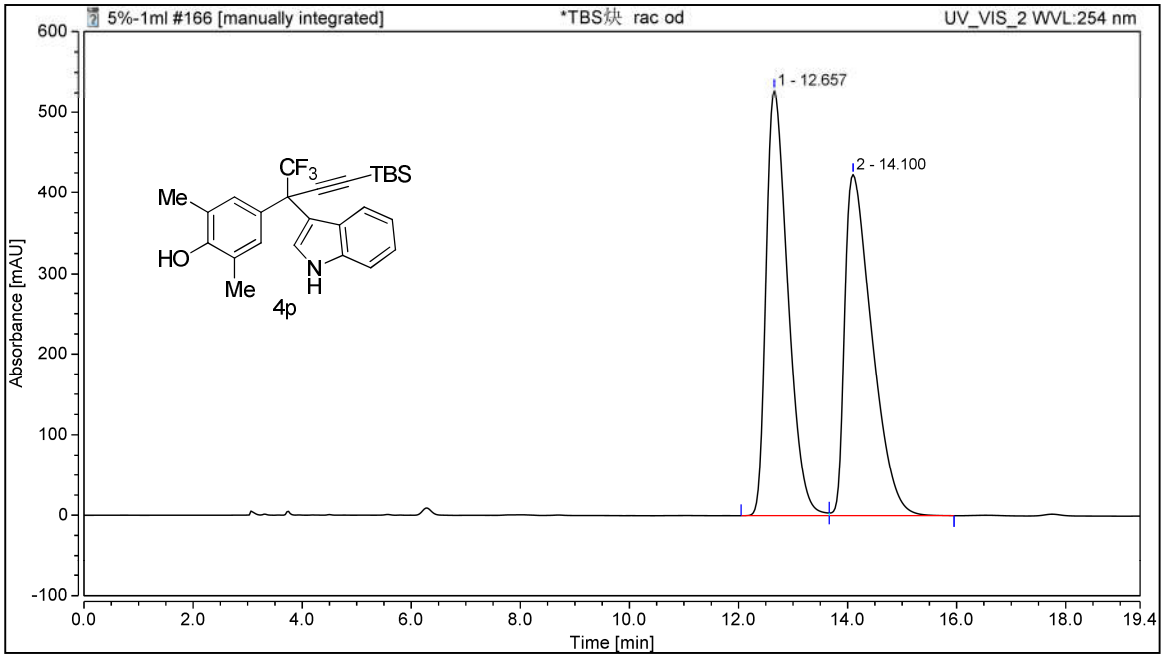
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.697	8.953	4.39	n.a.
2		9.317	195.187	95.61	n.a.
Total:			**204.140**	**100.00**	



Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		15.730	1396.735	49.81	n.a.
2		19.807	1407.295	50.19	n.a.
Total:			**2804.030**	**100.00**	

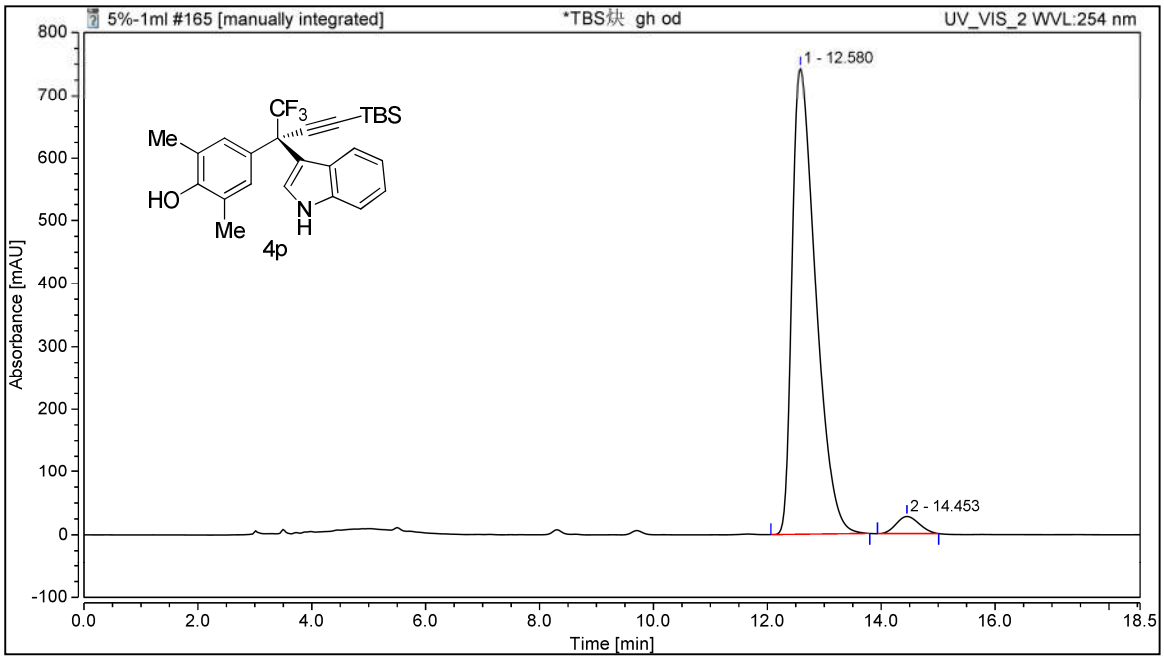


No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		15.707	500.964	93.11	n.a.
2		19.847	37.084	6.89	n.a.
Total:			**538.048**	**100.00**	



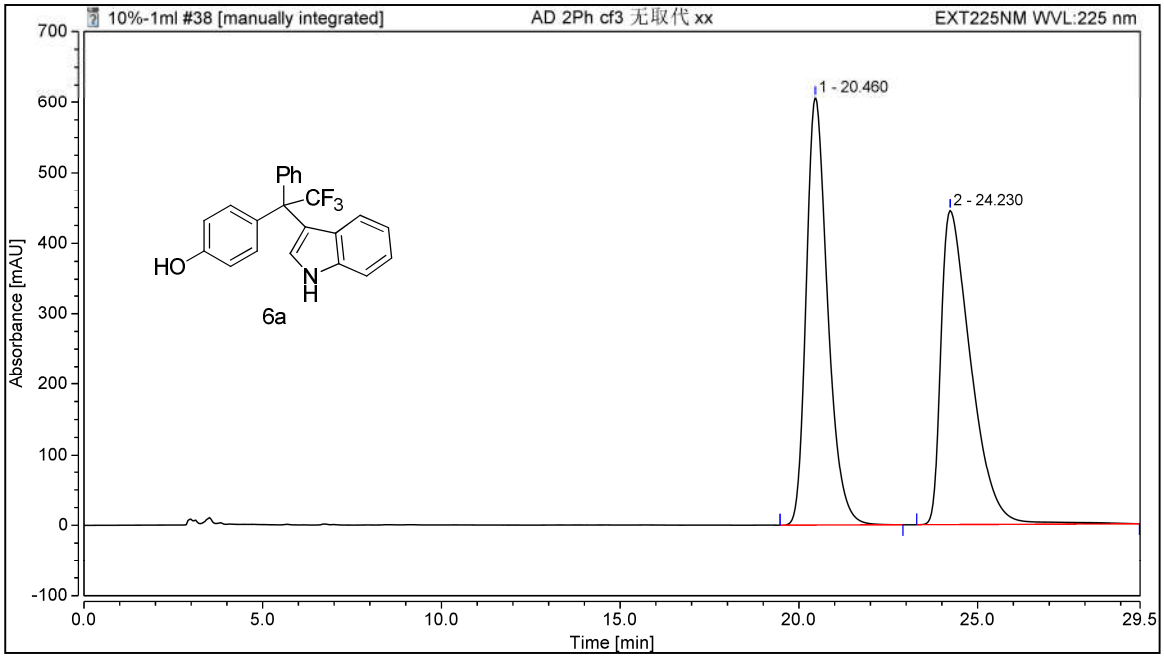
Integration Results

No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		12.657	244.239	49.94	n.a.
2		14.100	244.830	50.06	n.a.
Total:			**489.069**	**100.00**	

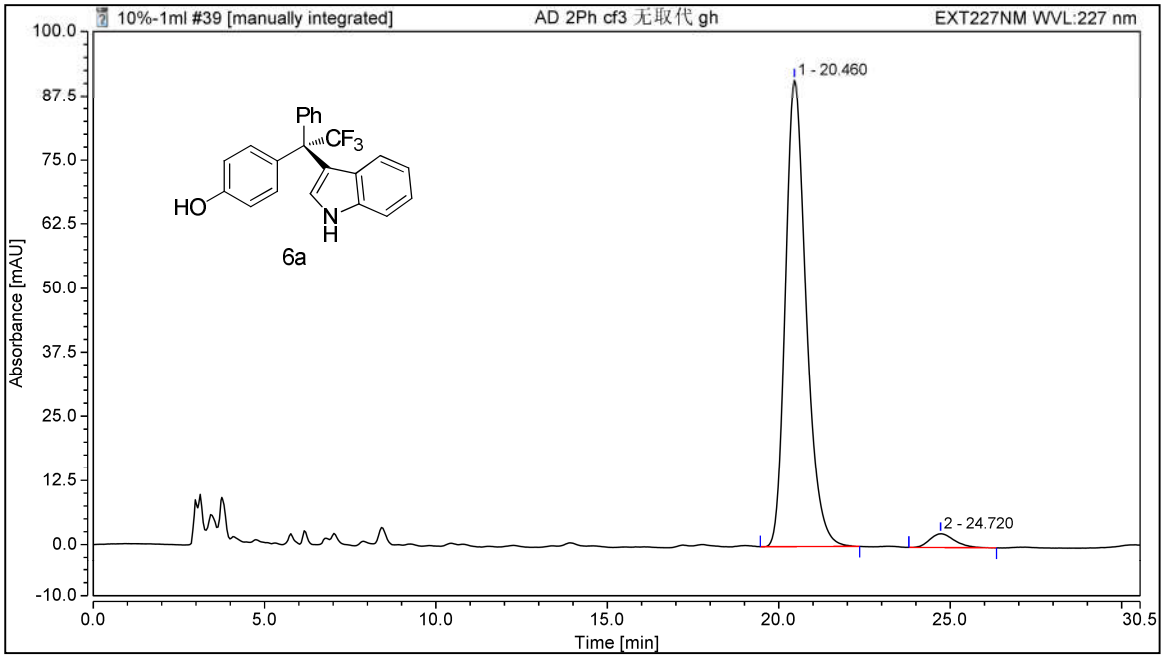


Integration Results

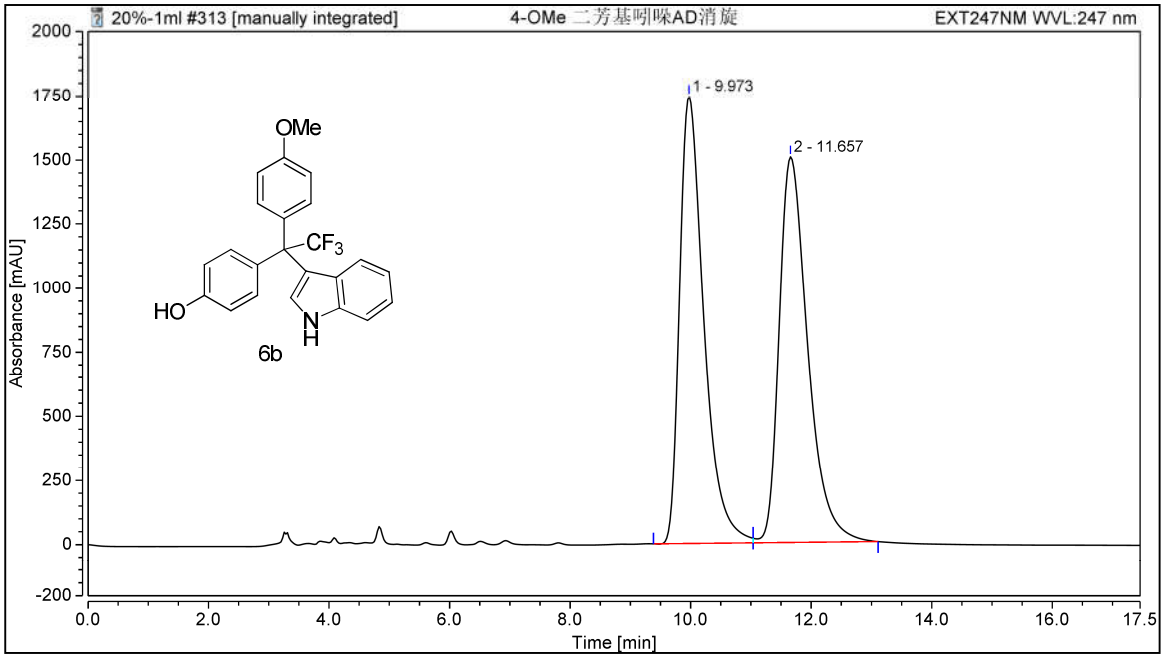
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		12.580	355.461	96.57	n.a.
2		14.453	12.629	3.43	n.a.
Total:			**368.091**	**100.00**	



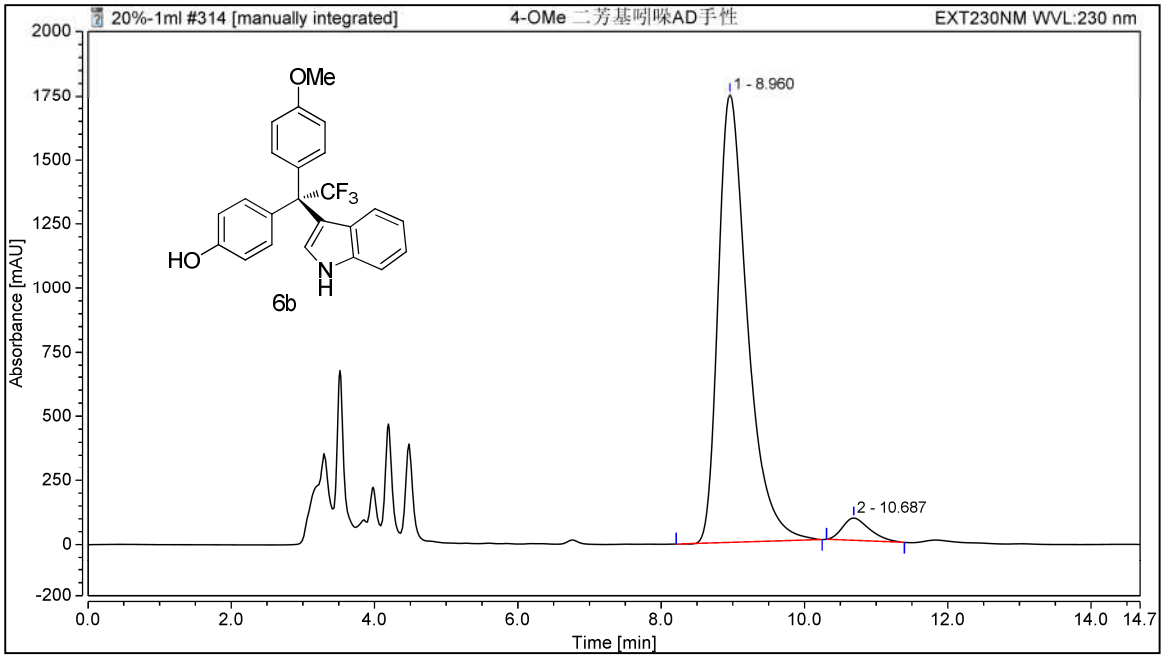
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		20.460	421.820	49.43	n.a.
2		24.230	431.583	50.57	n.a.
Total:			**853.403**	**100.00**	



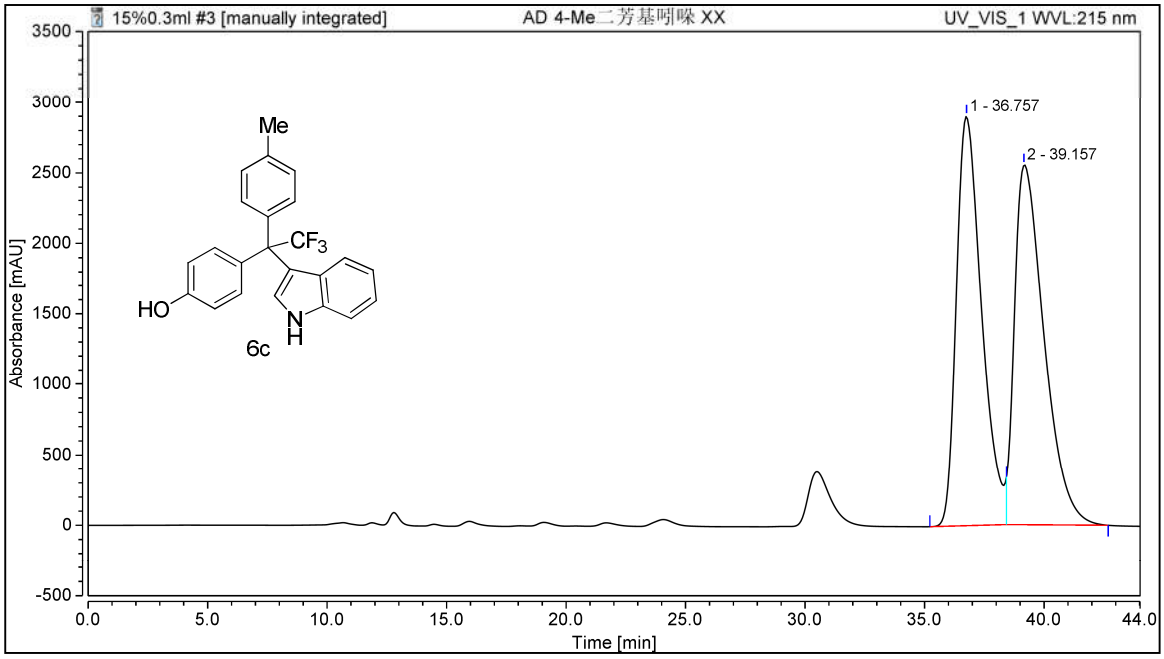
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		20.460	63.696	96.59	n.a.
2		24.720	2.247	3.41	n.a.
Total:			**65.943**	**100.00**	



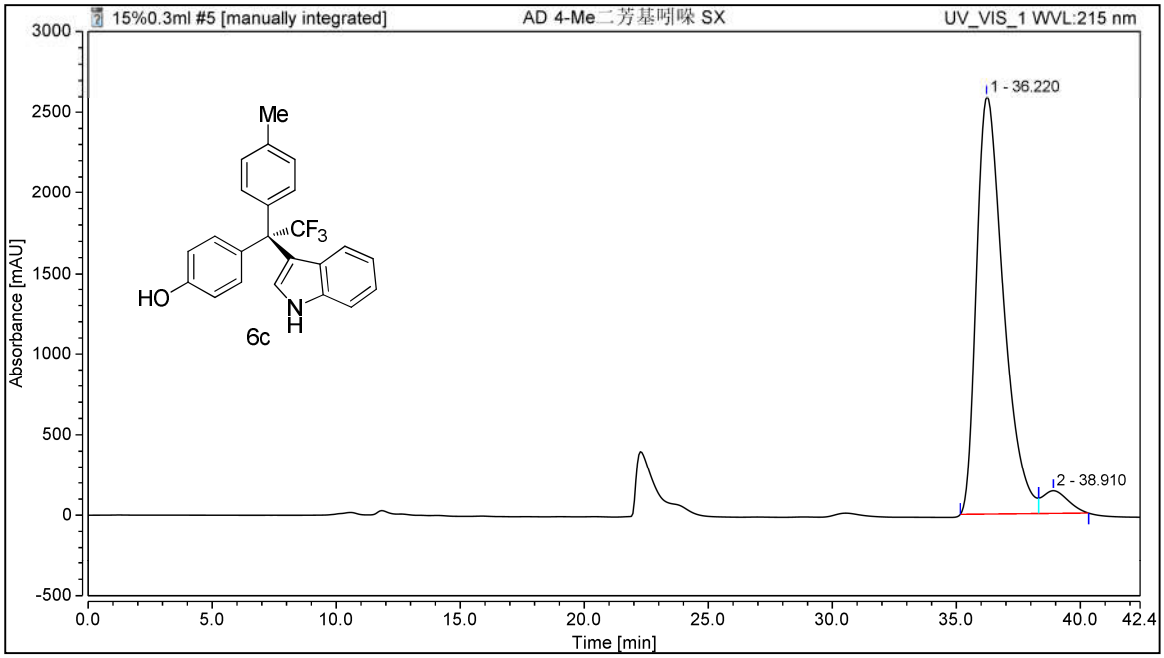
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		9.973	811.399	49.57	n.a.
2		11.657	825.485	50.43	n.a.
Total:			**1636.884**	**100.00**	



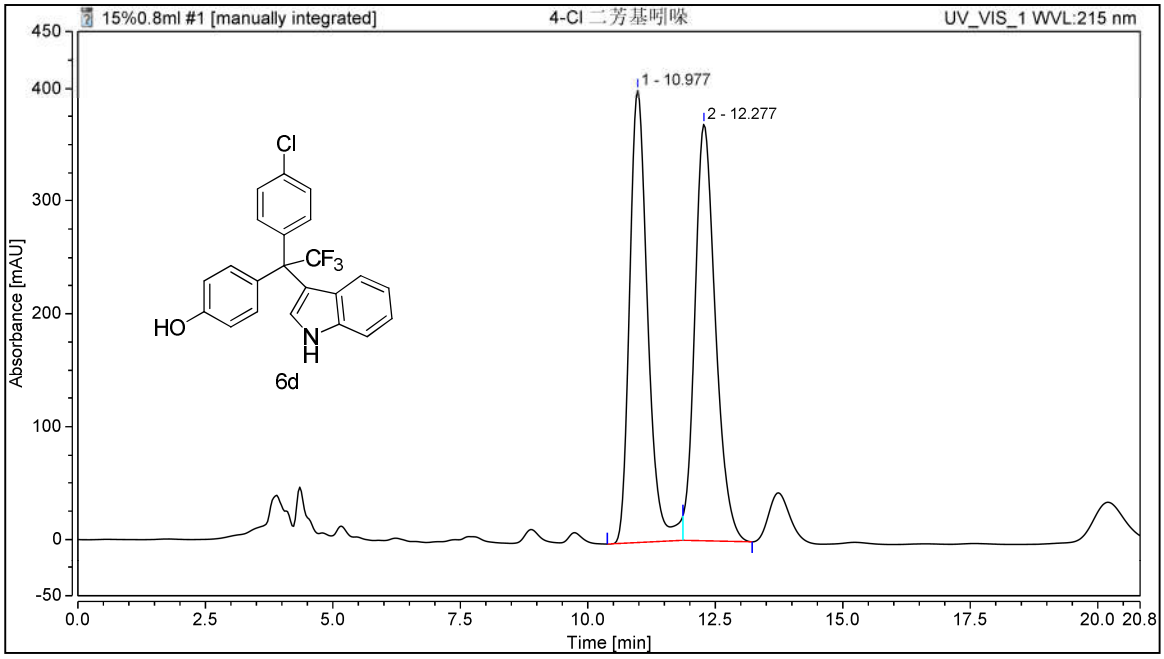
Integration Results					
No.	Peak Name	Retention Time min	Height mAU	Relative Area %	Amount n.a.
1		8.960	1748.946	95.59	n.a.
2		10.687	86.571	4.41	n.a.
Total:			**1835.517**	**100.00**	



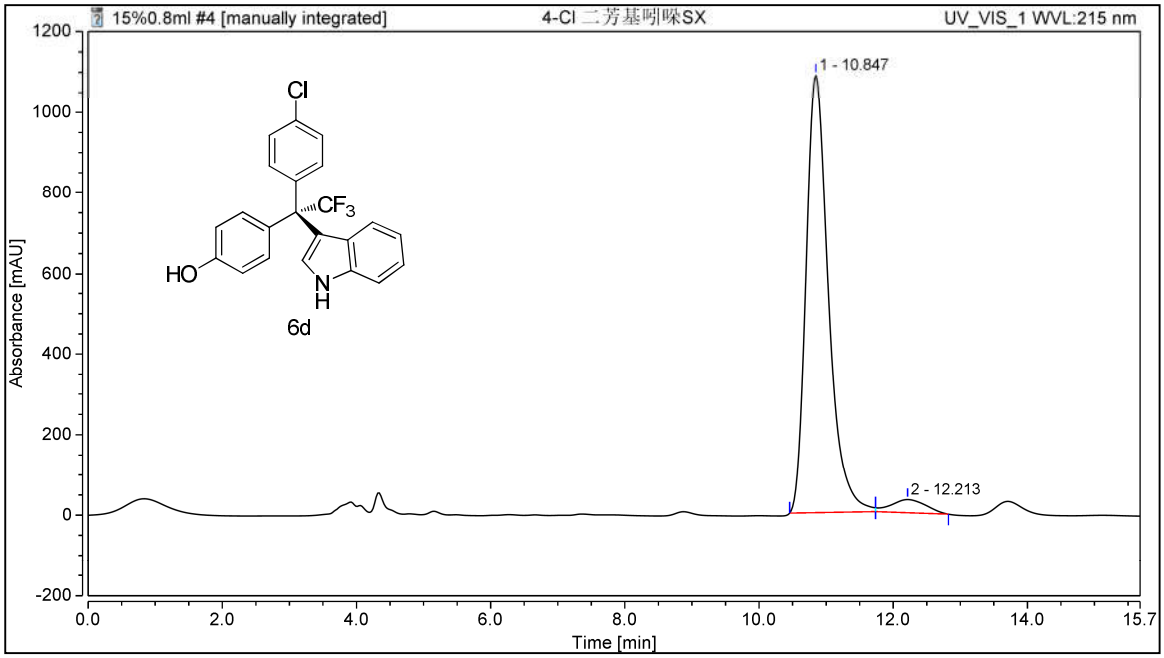
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		36.757	3557.996	49.40	n.a.
2		39.157	3644.874	50.60	n.a.
Total:			**7202.870**	**100.00**	



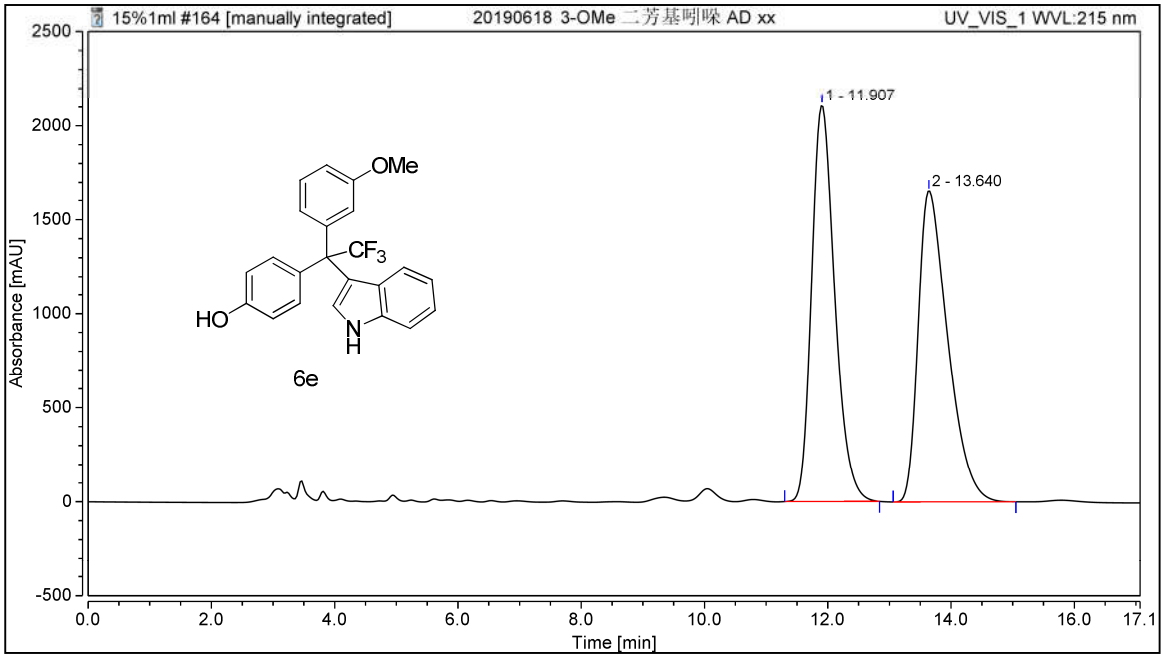
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		36.220	3268.815	95.14	n.a.
2		38.910	166.839	4.86	n.a.
Total:			**3435.654**	**100.00**	



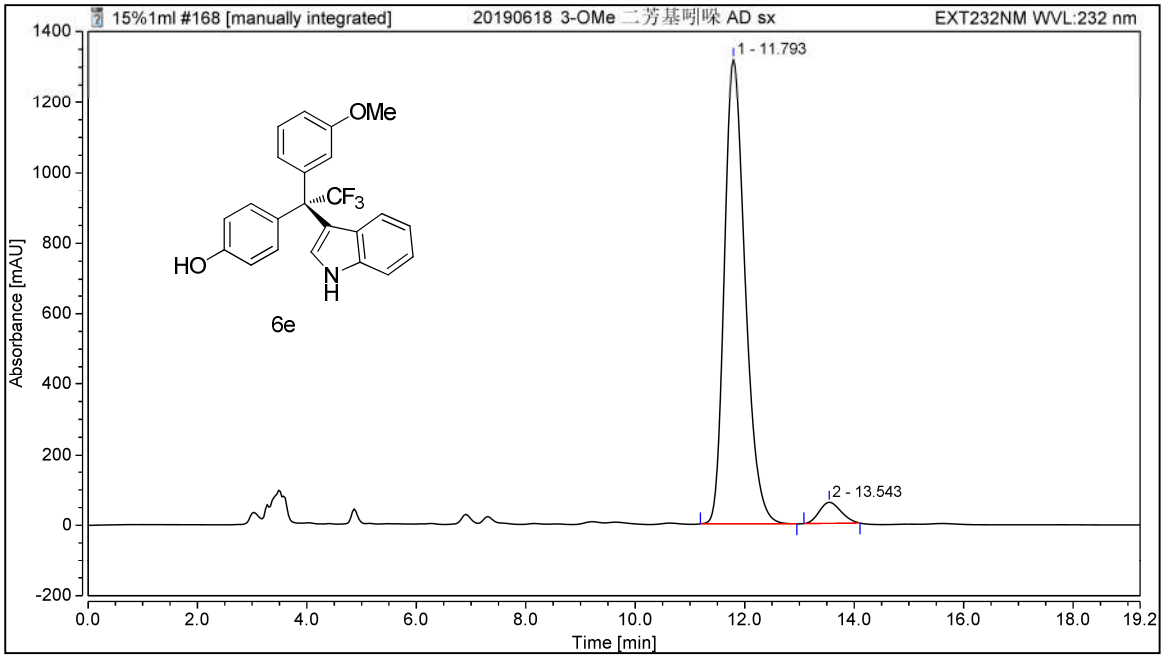
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		10.977	164.824	48.79	n.a.
2		12.277	172.996	51.21	n.a.
Total:			**337.820**	**100.00**	



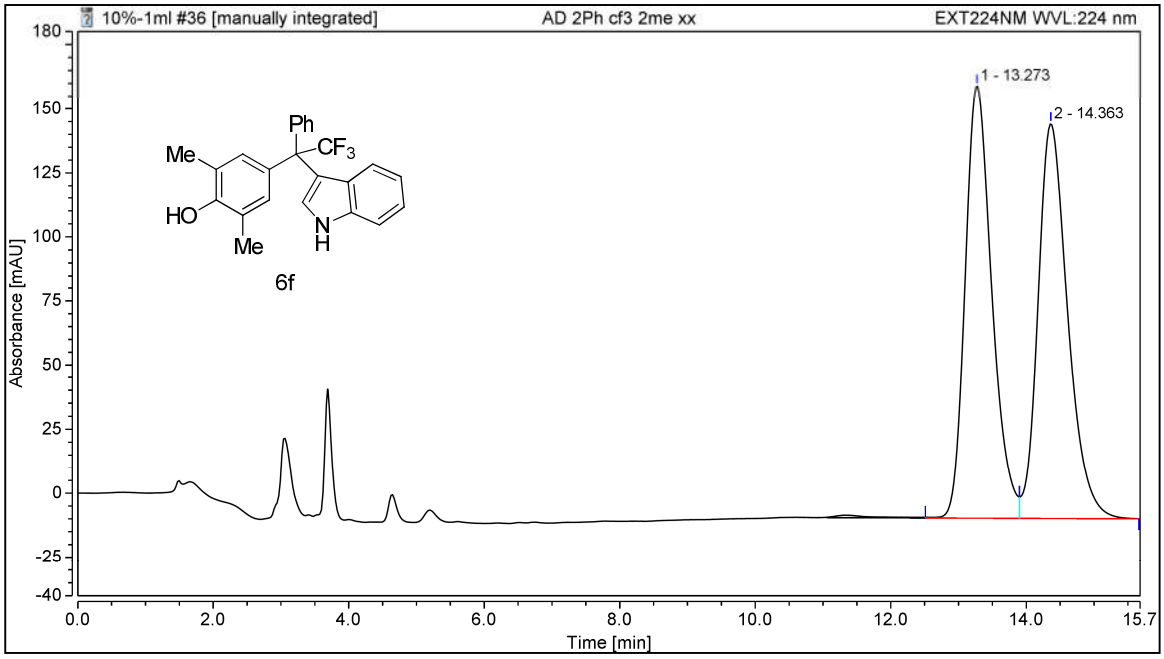
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		10.847	419.180	95.50	n.a.
2		12.213	19.764	4.50	n.a.
Total:			**438.944**	**100.00**	



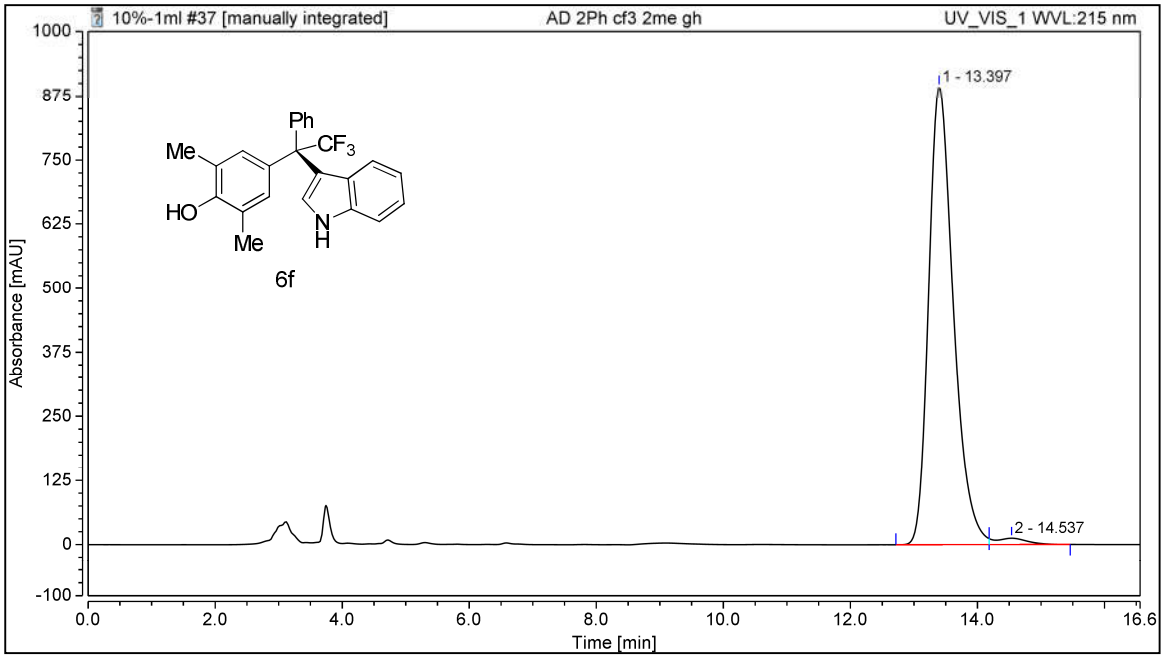
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		11.907	915.139	49.93	n.a.
2		13.640	917.875	50.07	n.a.
Total:			**1833.014**	**100.00**	



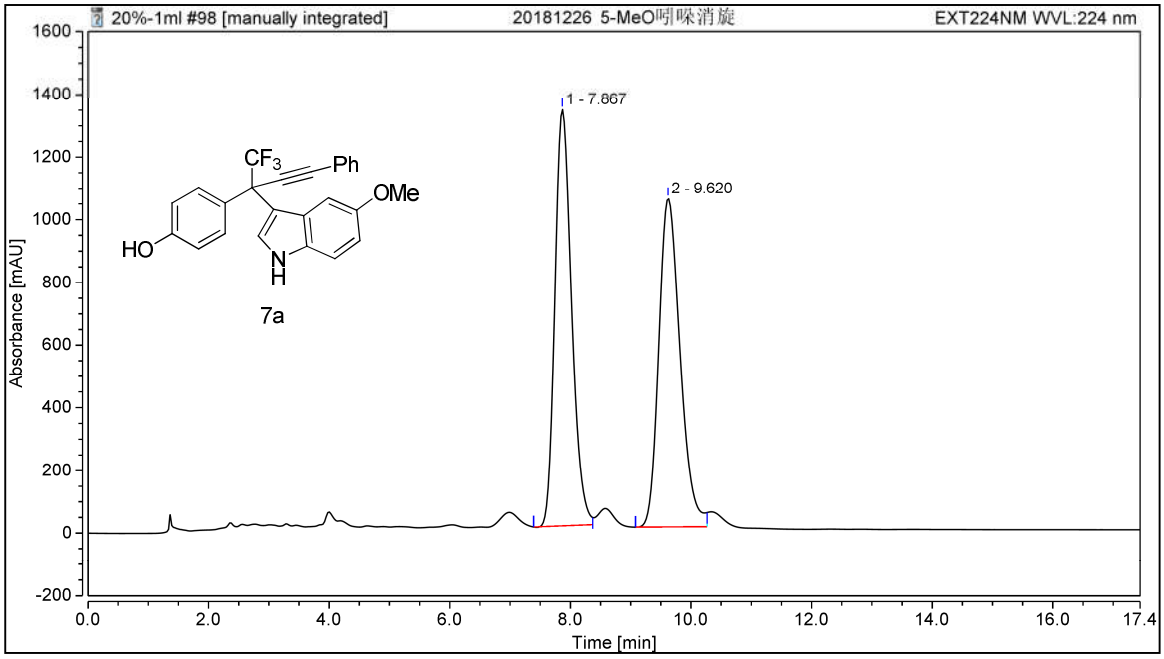
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		11.793	578.687	95.48	n.a.
2		13.543	27.396	4.52	n.a.
Total:			**606.083**	**100.00**	



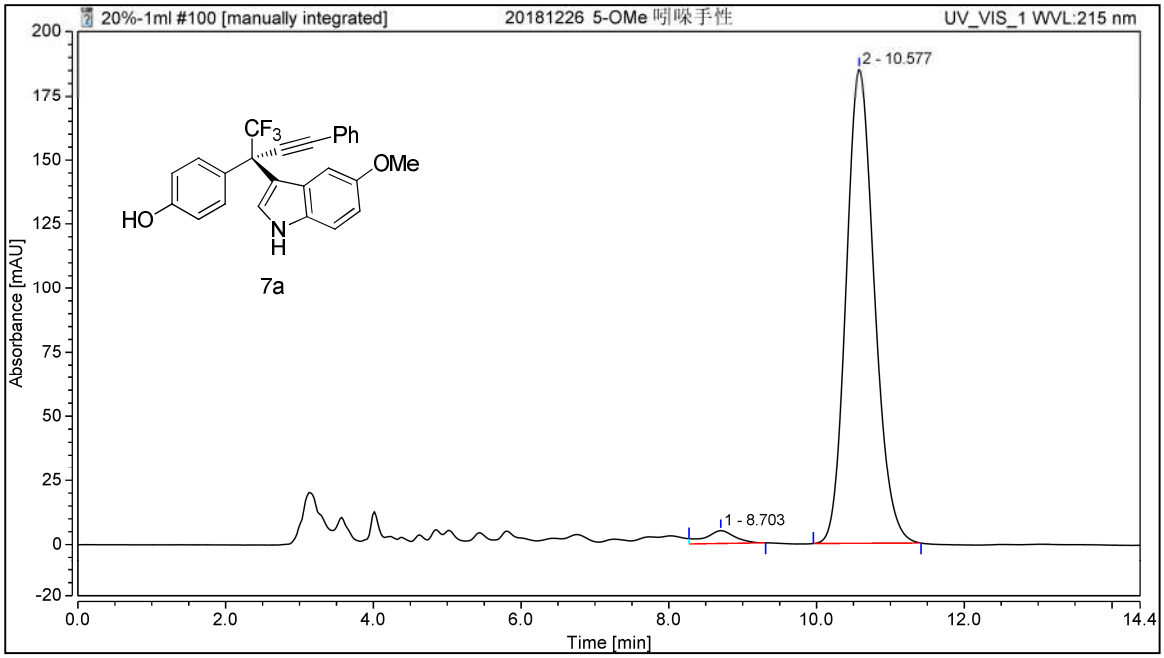
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.273	76.886	49.62	n.a.
2		14.363	78.078	50.38	n.a.
Total:			**154.965**	**100.00**	



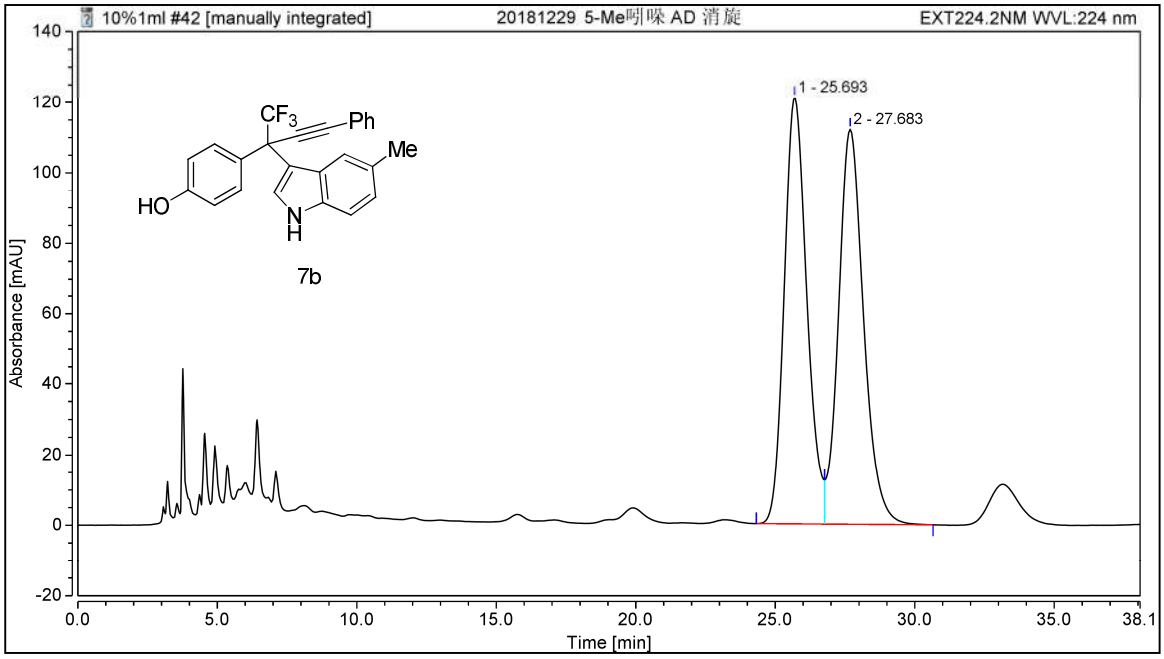
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		13.397	401.569	98.24	n.a.
2		14.537	7.192	1.76	n.a.
Total:			**408.761**	**100.00**	



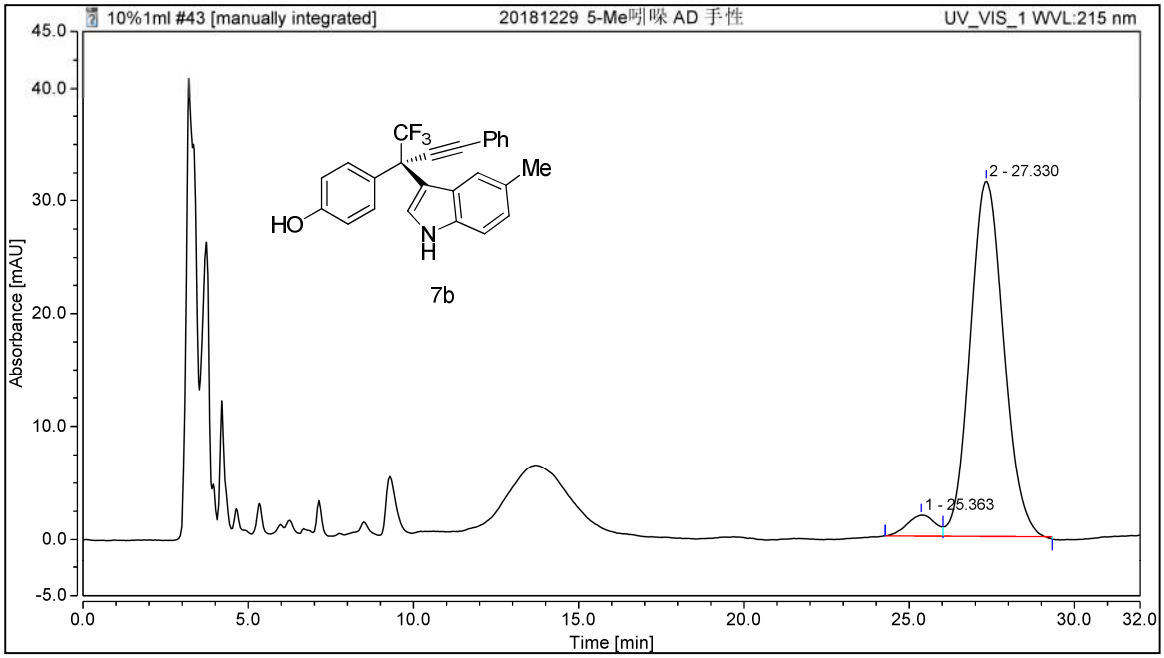
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.867	424.934	49.75	n.a.
2		9.620	429.137	50.25	n.a.
Total:			**854.071**	**100.00**	



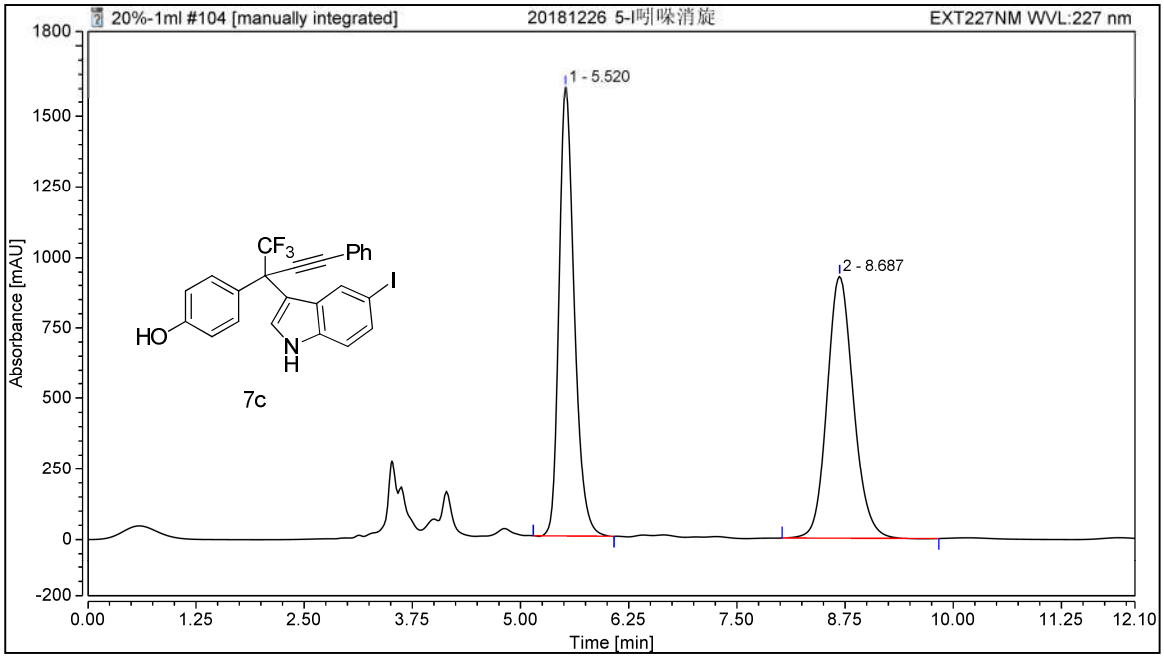
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		8.703	1.948	2.33	n.a.
2		10.577	81.678	97.67	n.a.
Total:			**83.626**	**100.00**	



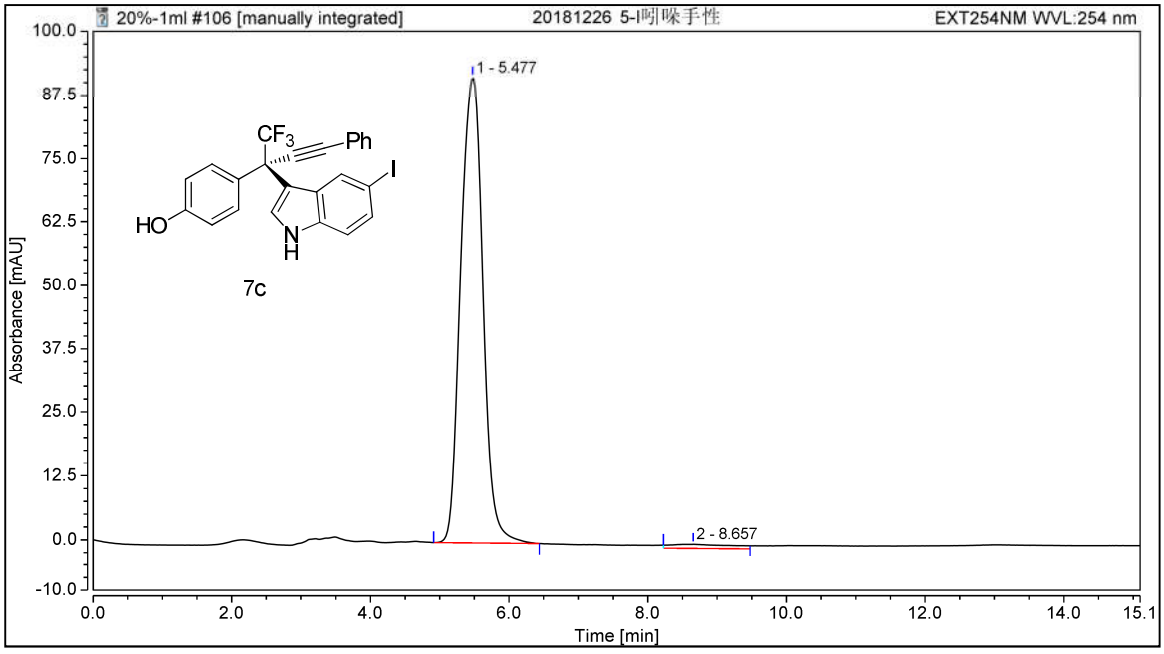
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		25.693	113.412	49.31	n.a.
2		27.683	116.578	50.69	n.a.
Total:			**229.990**	**100.00**	



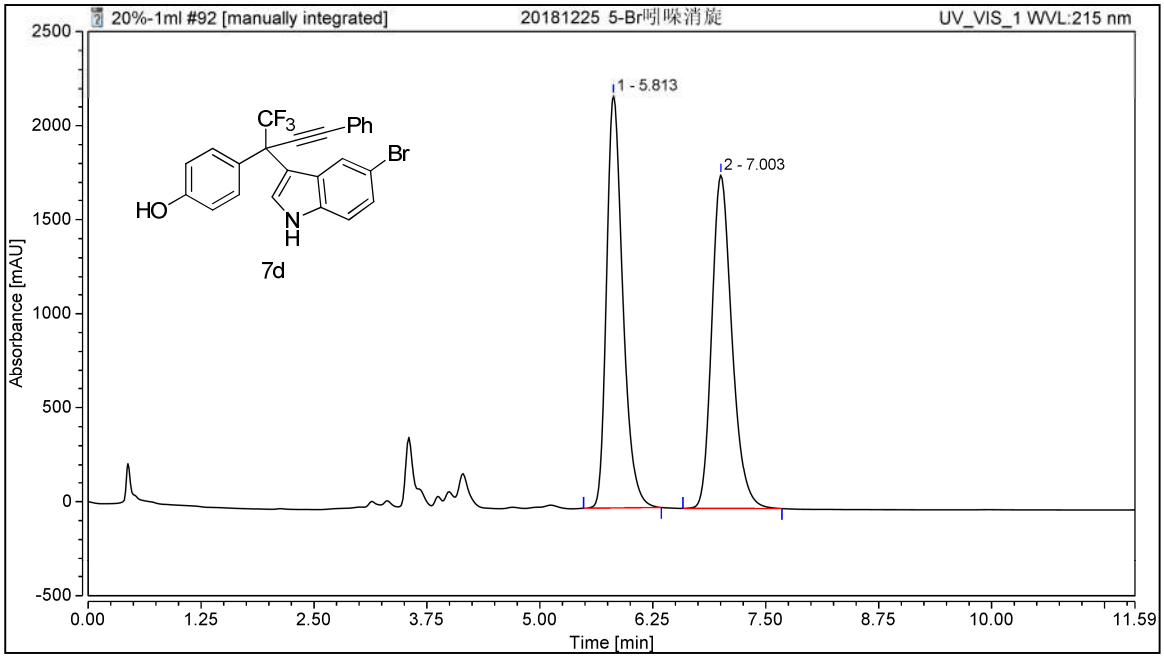
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		25.420	1.237	4.88	n.a.
2		27.323	24.090	95.12	n.a.
Total:			**25.327**	**100.00**	



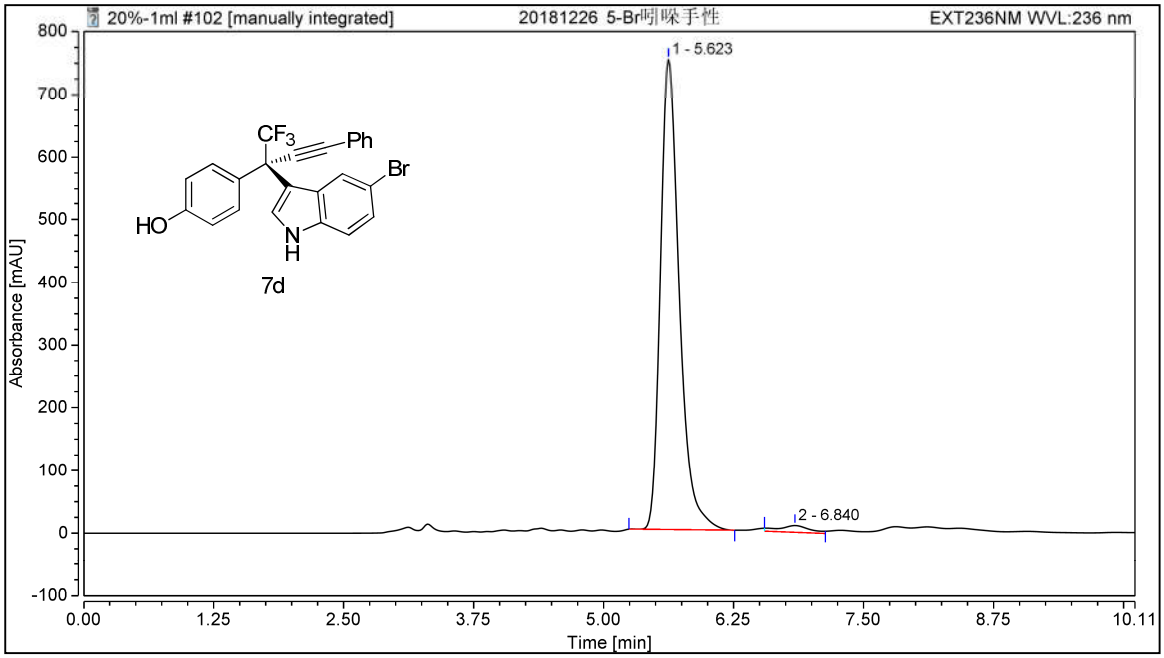
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		5.520	324.727	49.80	n.a.
2		8.687	327.276	50.20	n.a.
Total:			**652.003**	**100.00**	



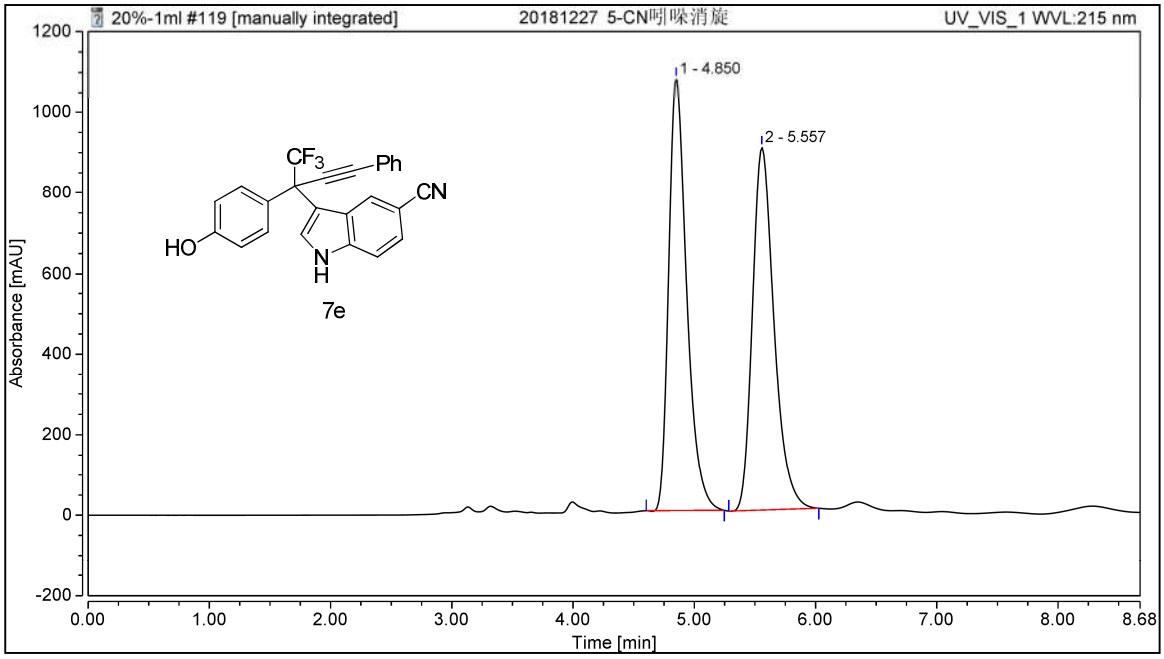
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		5.477	34.035	97.56	n.a.
2		8.657	0.850	2.44	n.a.
Total:			**34.885**	**100.00**	



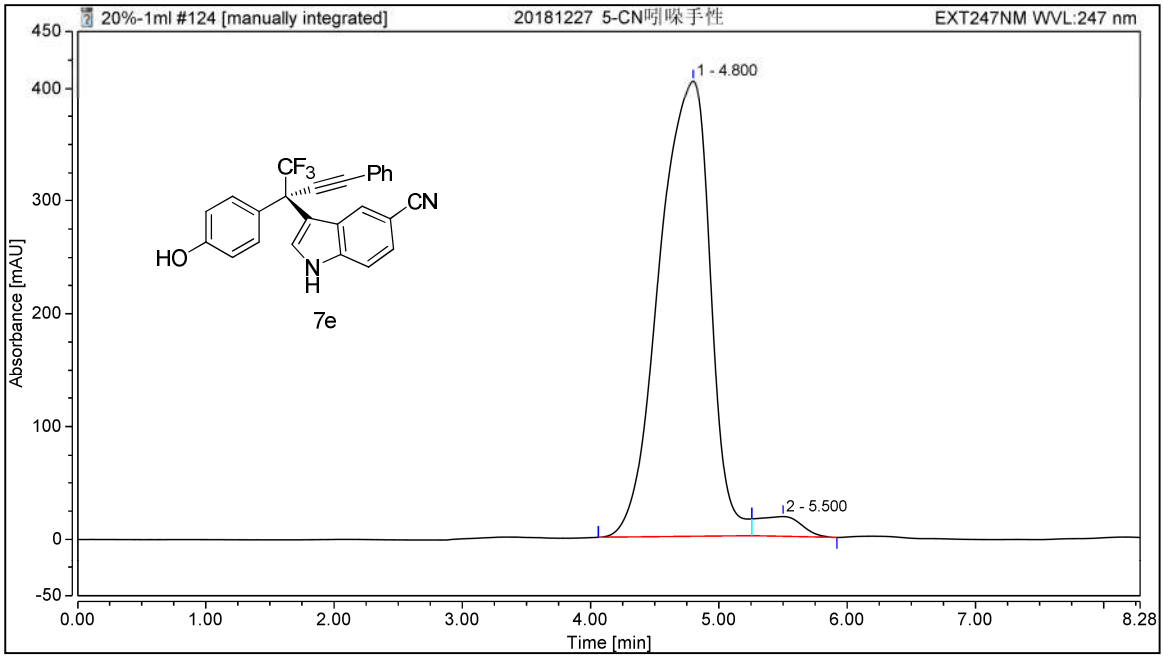
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		5.813	458.454	49.99	n.a.
2		7.003	458.582	50.01	n.a.
Total:			**917.036**	**100.00**	



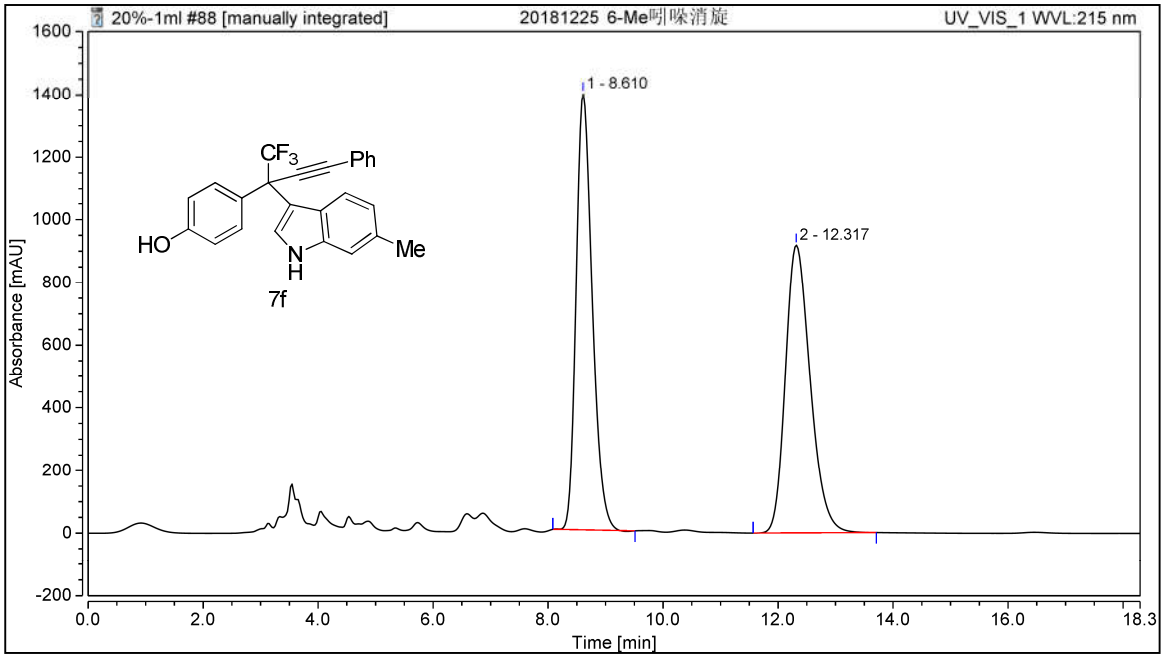
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		5.623	157.889	97.68	n.a.
2		6.840	3.752	2.32	n.a.
Total:			**161.641**	**100.00**	



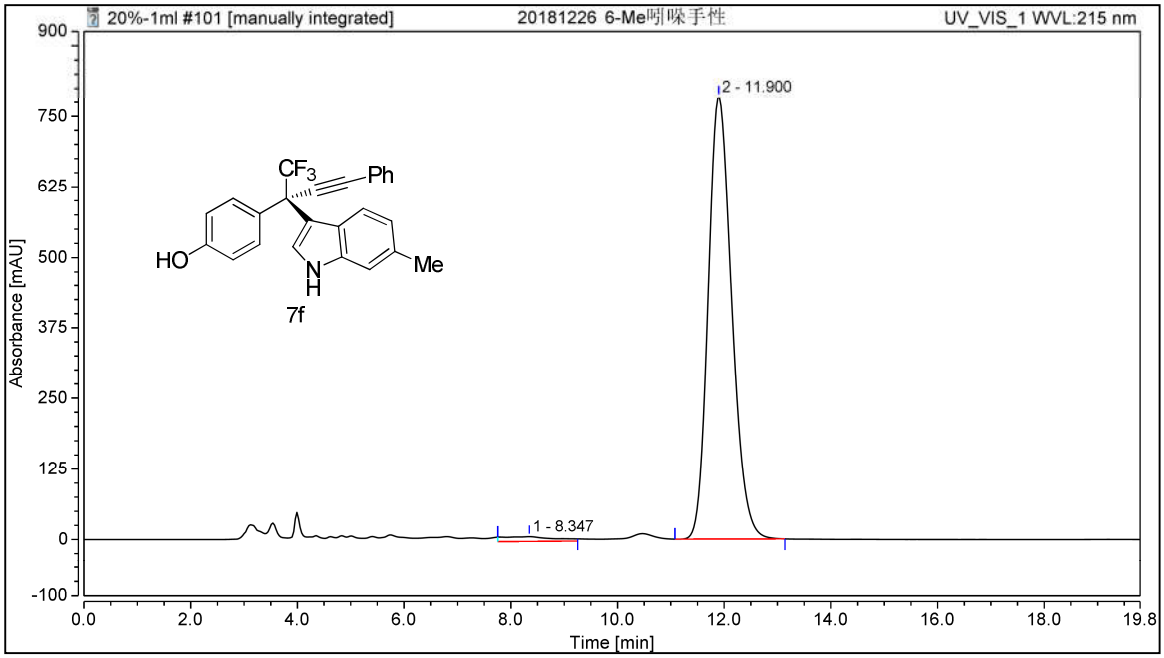
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		4.850	184.602	49.86	n.a.
2		5.557	185.611	50.14	n.a.
Total:			**370.213**	**100.00**	



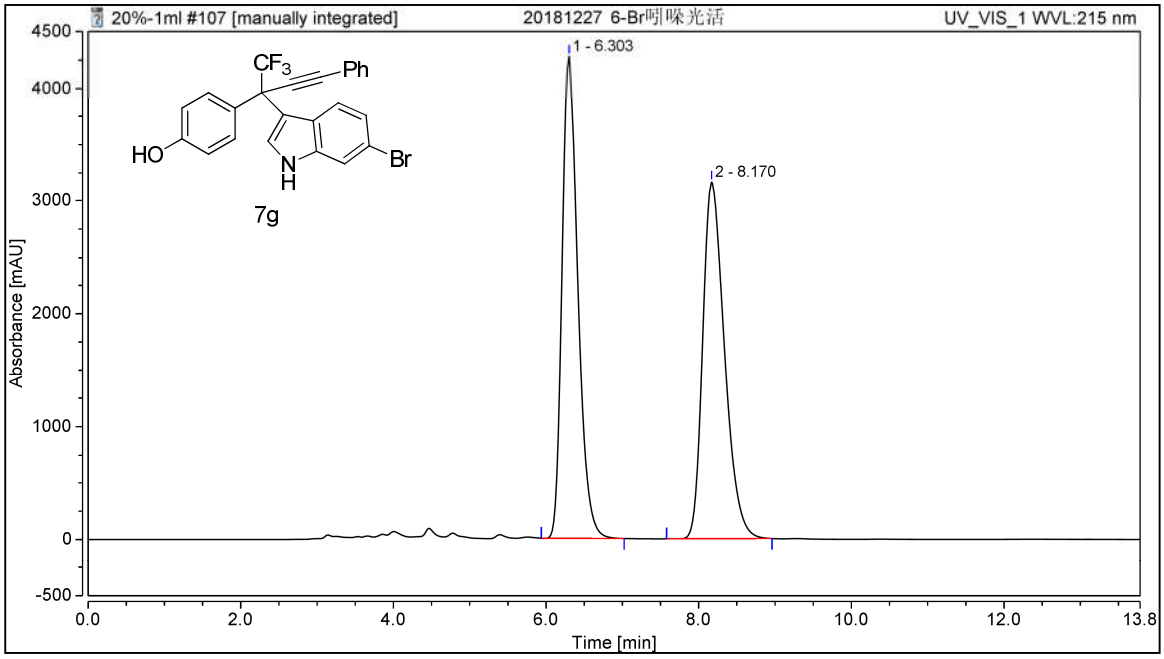
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		4.800	185.441	96.40	n.a.
2		5.500	6.921	3.60	n.a.
Total:			**192.362**	**100.00**	



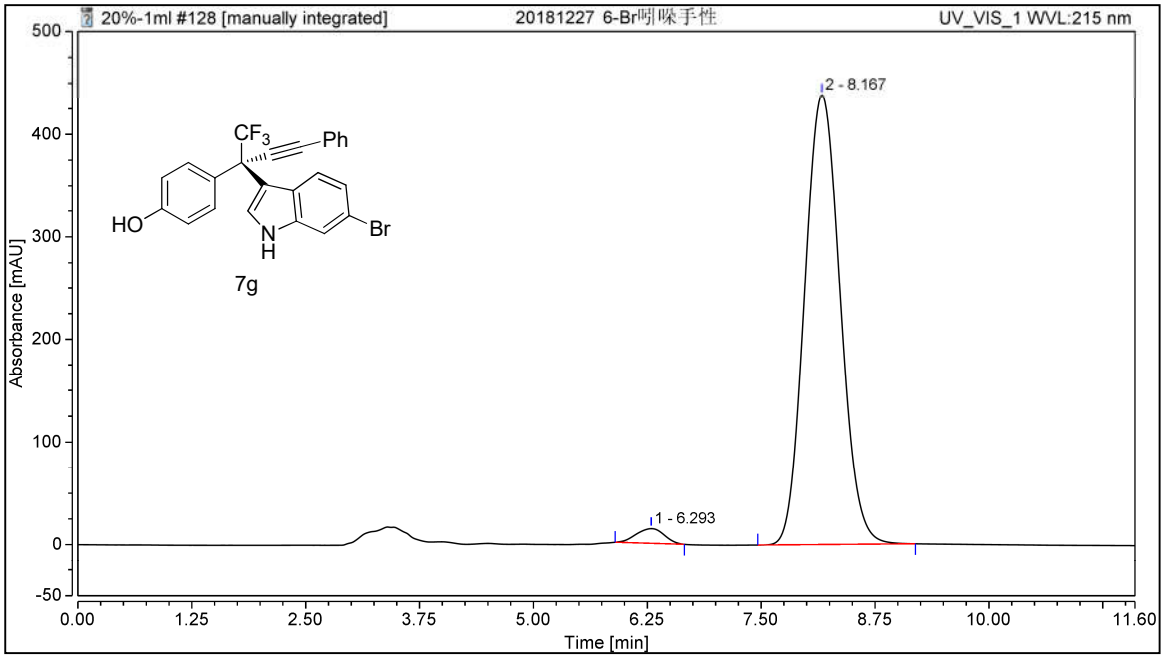
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		8.610	451.942	49.59	n.a.
2		12.317	459.405	50.41	n.a.
Total:			**911.347**	**100.00**	



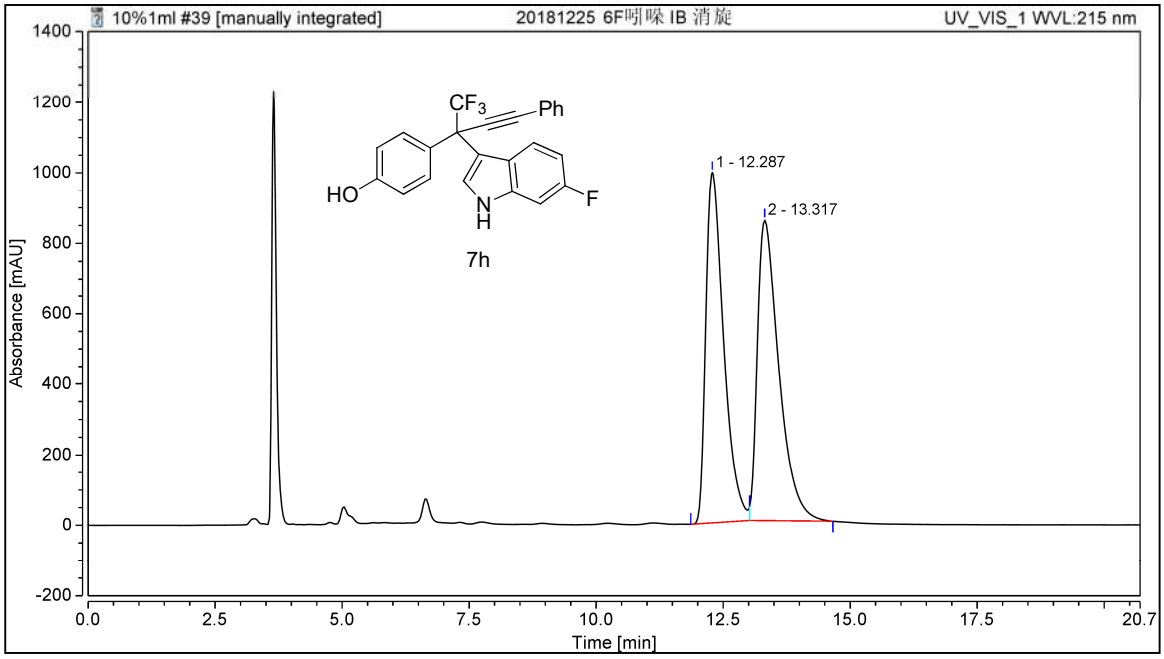
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		8.347	8.559	2.09	n.a.
2		11.900	400.564	97.91	n.a.
Total:			**409.123**	**100.00**	



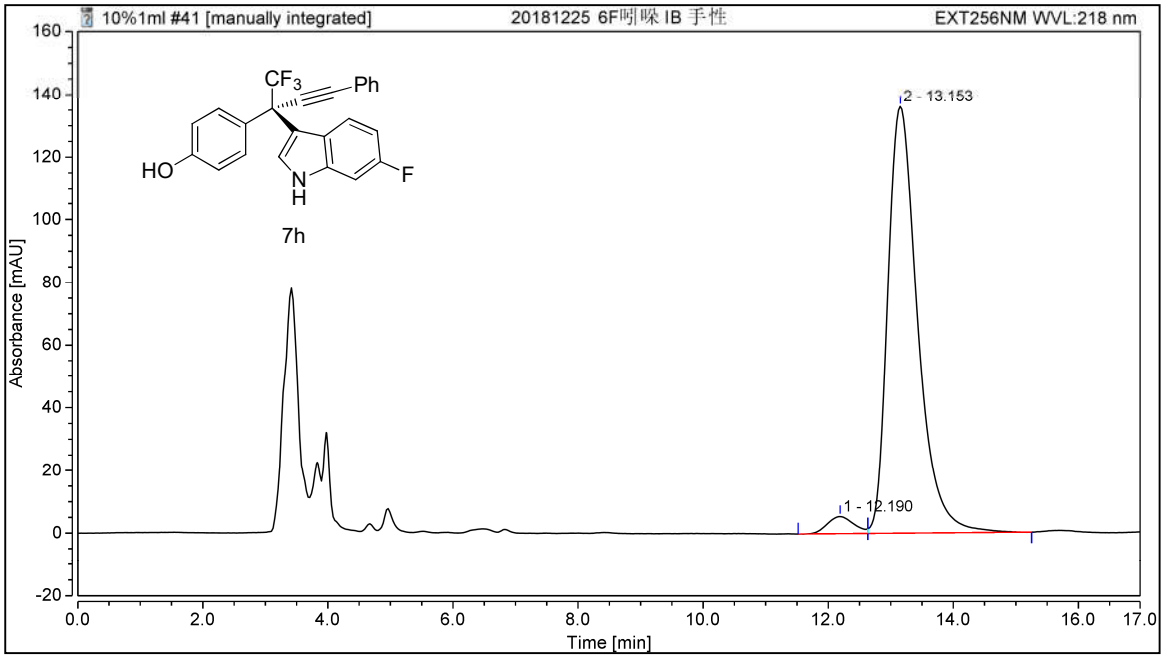
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.303	1027.966	49.62	n.a.
2		8.170	1043.722	50.38	n.a.
Total:			**2071.687**	**100.00**	



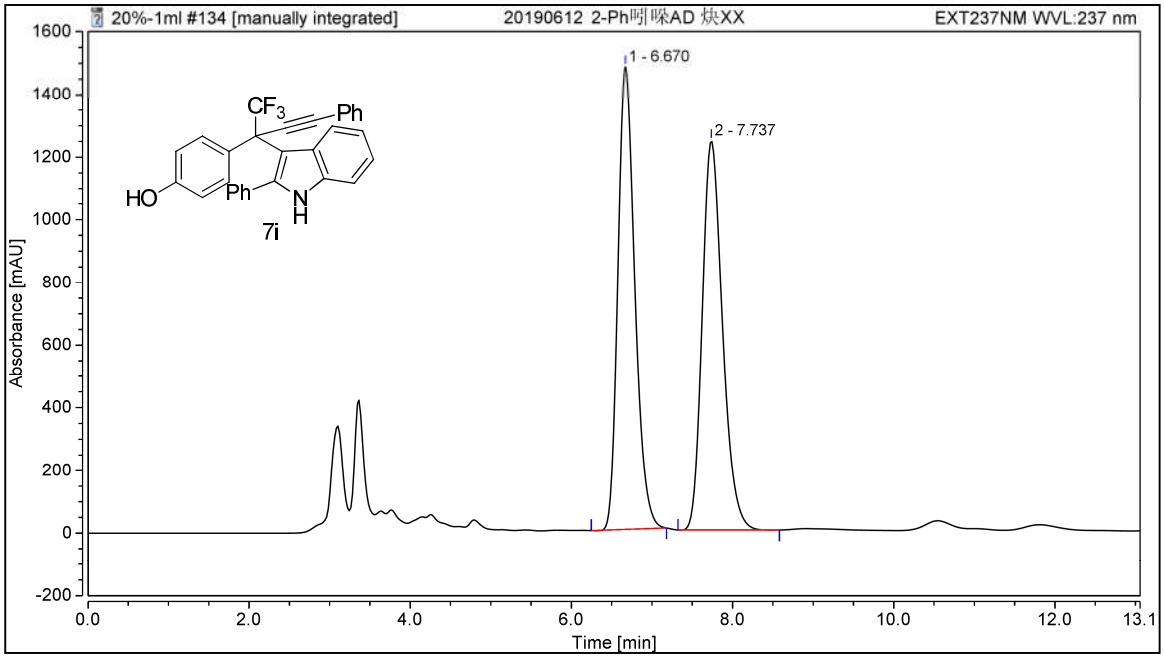
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.293	5.082	2.50	n.a.
2		8.167	197.806	97.50	n.a.
Total:			**202.888**	**100.00**	



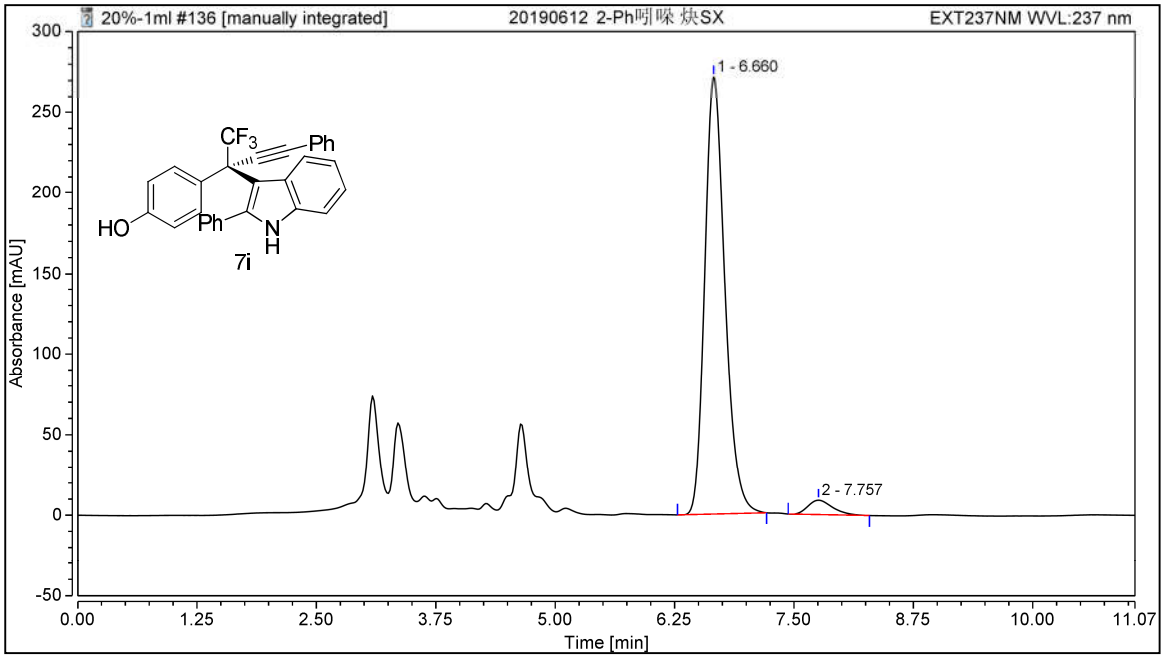
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		12.287	405.362	49.26	n.a.
2		13.317	417.541	50.74	n.a.
Total:			**822.903**	**100.00**	



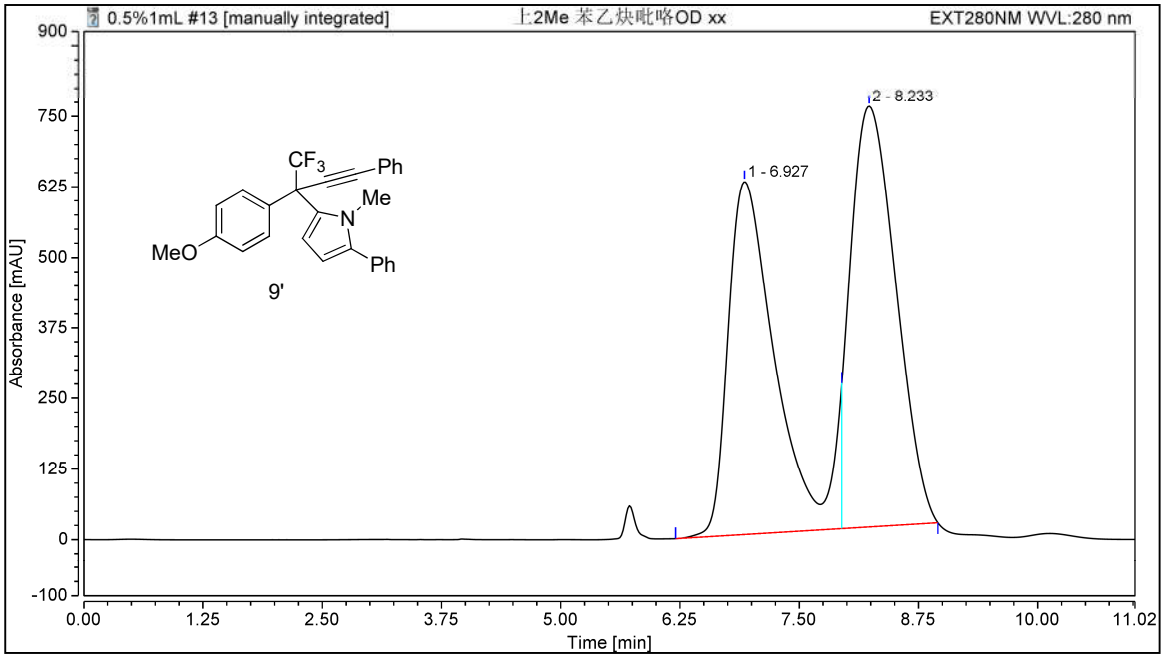
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		12.190	2.681	3.45	n.a.
2		13.153	75.079	96.55	n.a.
Total:			**77.760**	**100.00**	



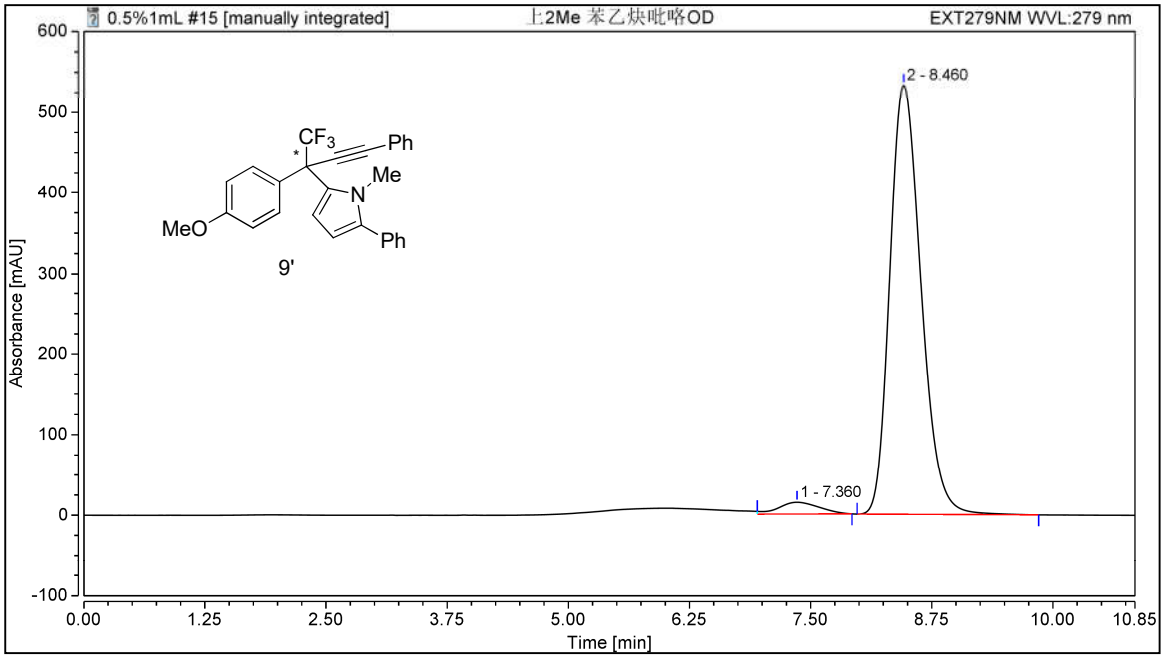
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.670	359.581	49.84	n.a.
2		7.737	361.928	50.16	n.a.
Total:			**721.509**	**100.00**	



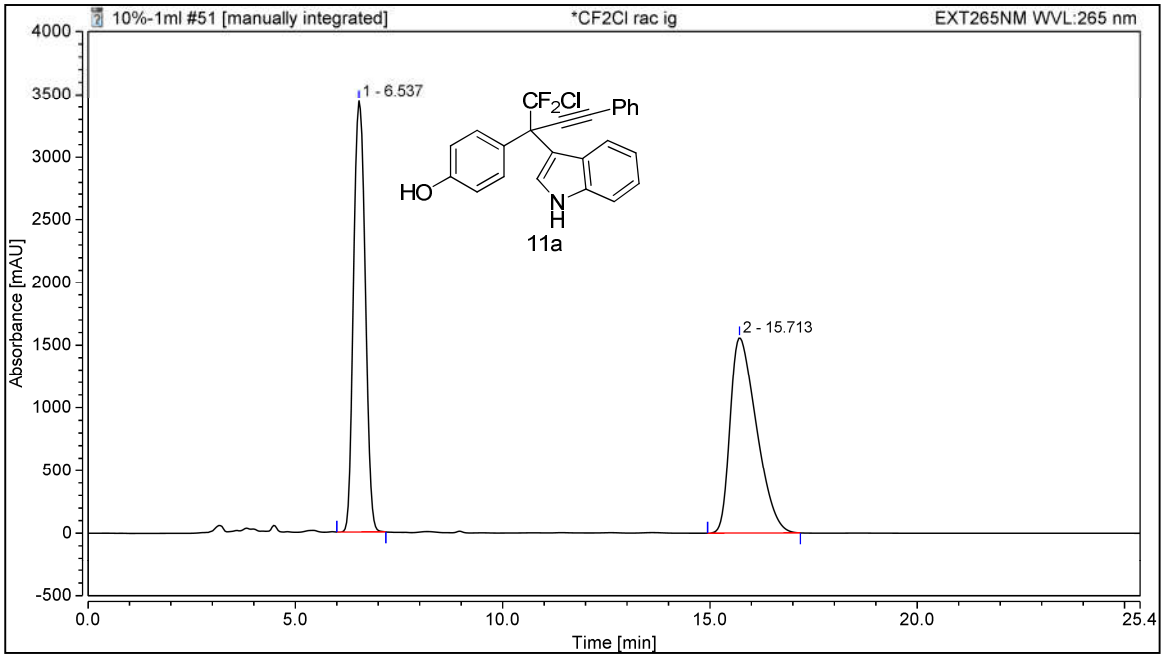
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.660	66.229	96.16	n.a.
2		7.757	2.644	3.84	n.a.
Total:			**68.872**	**100.00**	



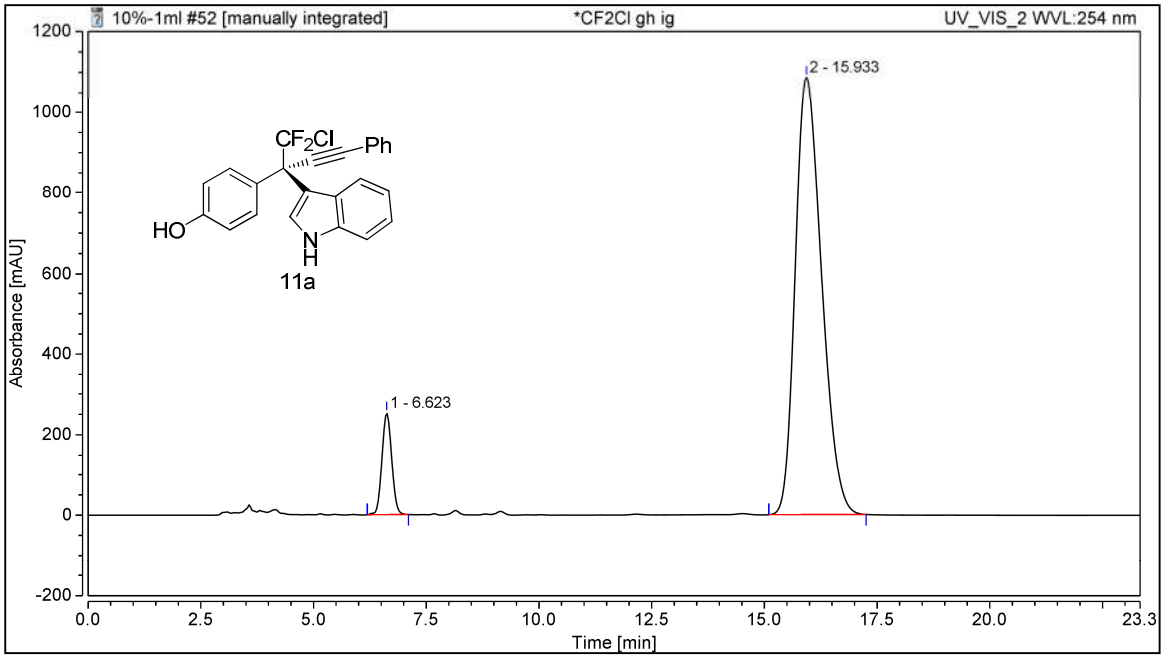
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.927	366.917	47.48	n.a.
2		8.233	405.908	52.52	n.a.
Total:			**772.825**	**100.00**	



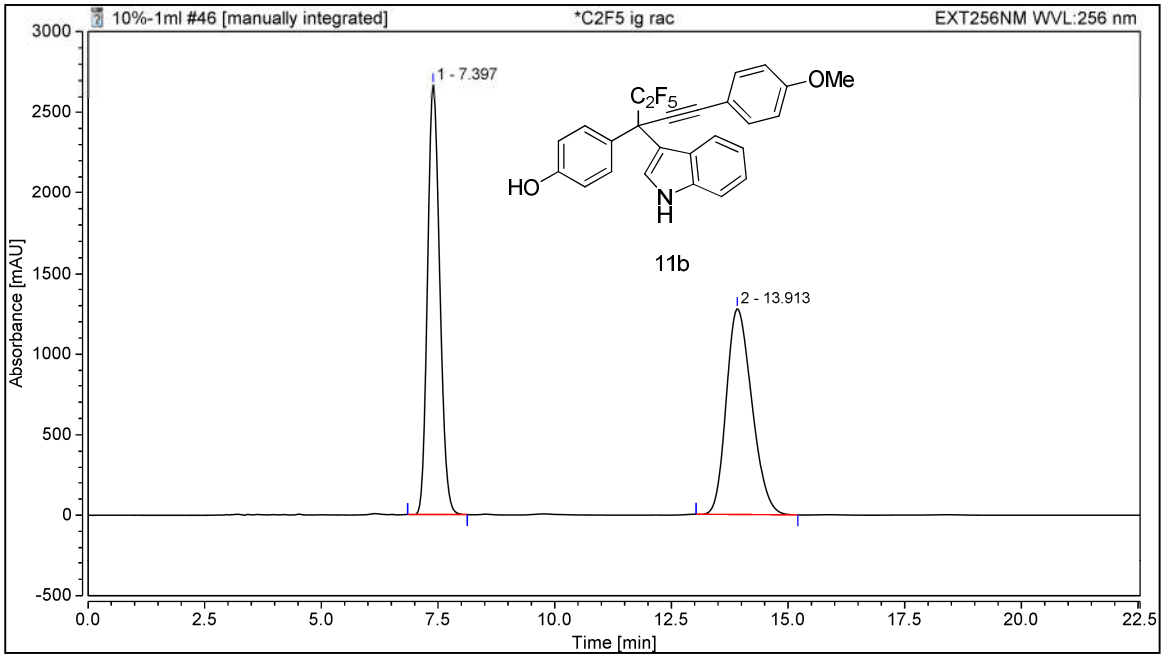
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.360	7.121	3.46	n.a.
2		8.460	198.494	96.54	n.a.
Total:			**205.616**	**100.00**	



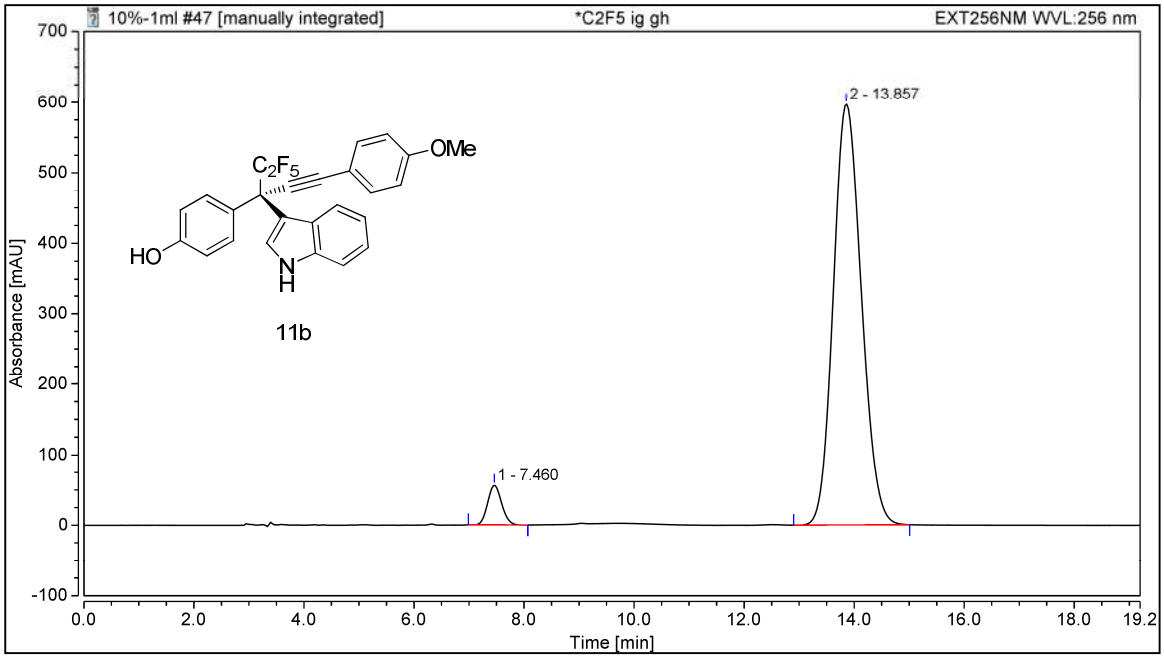
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.537	1128.852	49.58	n.a.
2		15.713	1148.016	50.42	n.a.
Total:			**2276.868**	**100.00**	



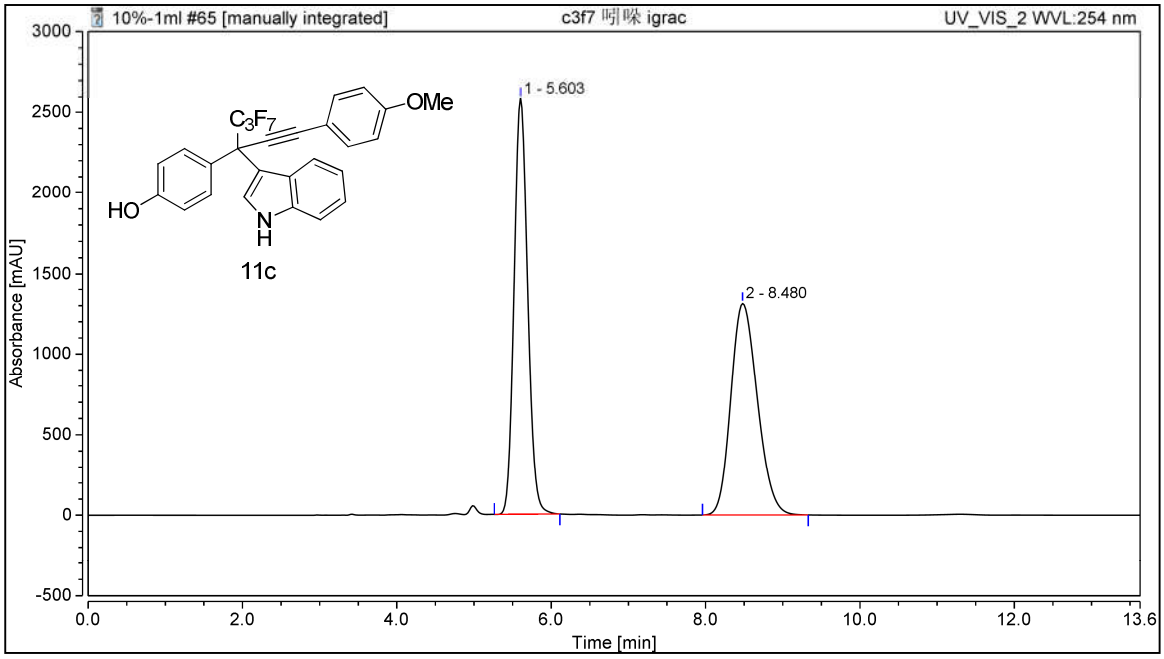
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		6.623	63.351	7.93	n.a.
2		15.933	735.133	92.07	n.a.
Total:			**798.484**	**100.00**	



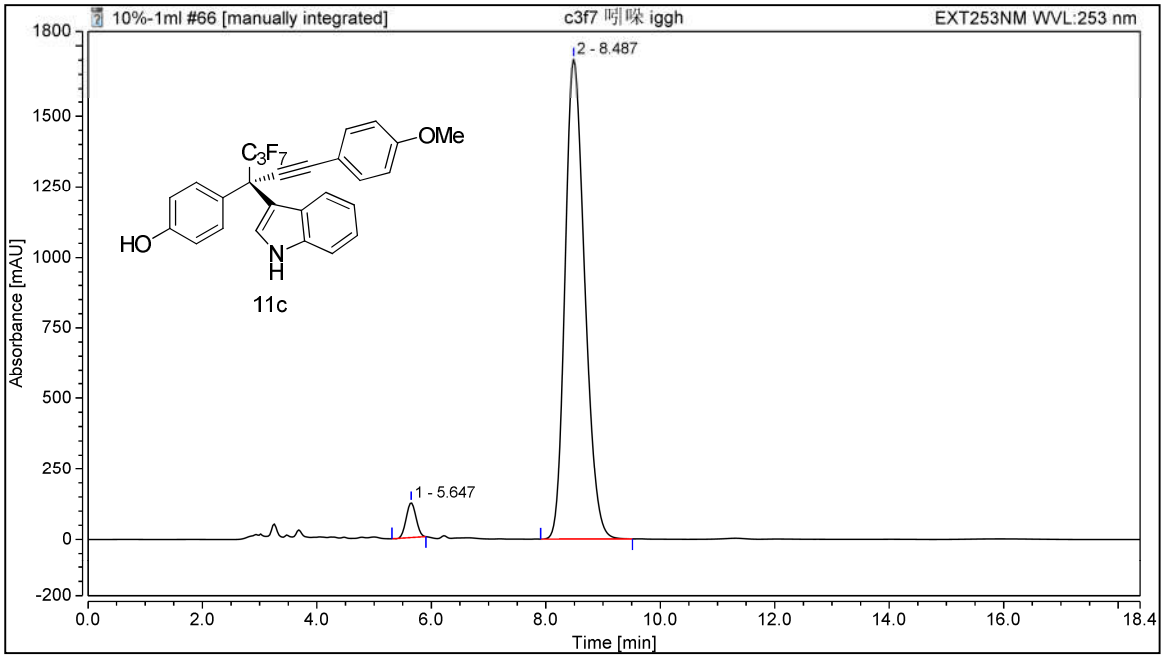
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.397	780.637	49.99	n.a.
2		13.913	780.893	50.01	n.a.
Total:			**1561.530**	**100.00**	



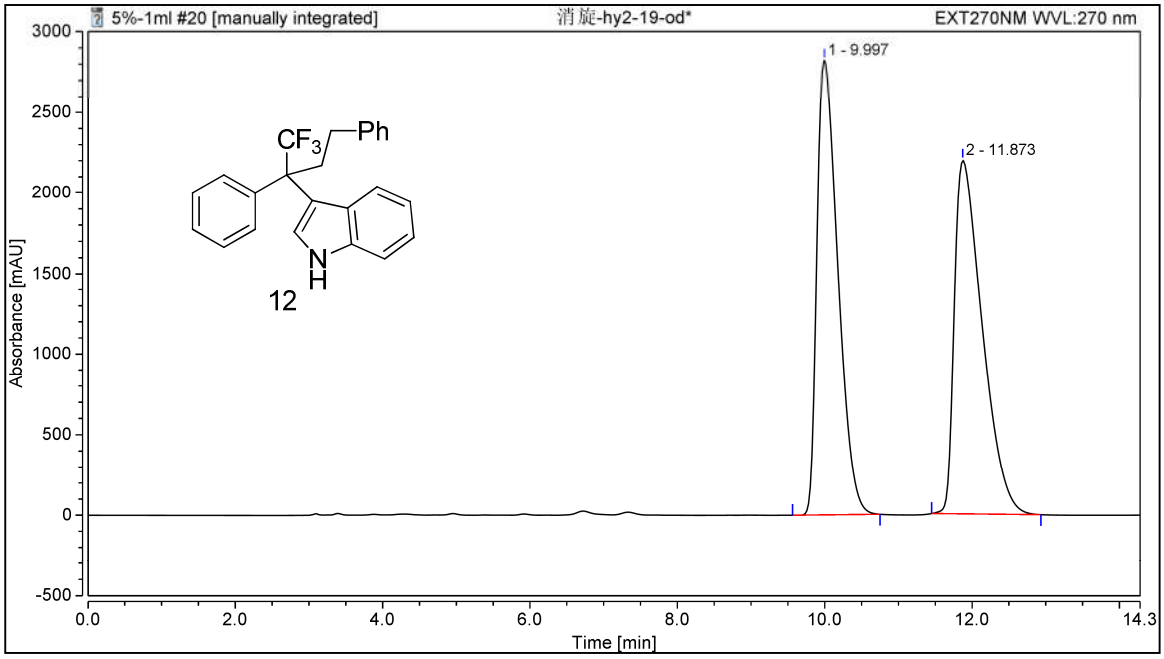
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		7.460	16.358	4.44	n.a.
2		13.857	352.246	95.56	n.a.
Total:			**368.604**	**100.00**	



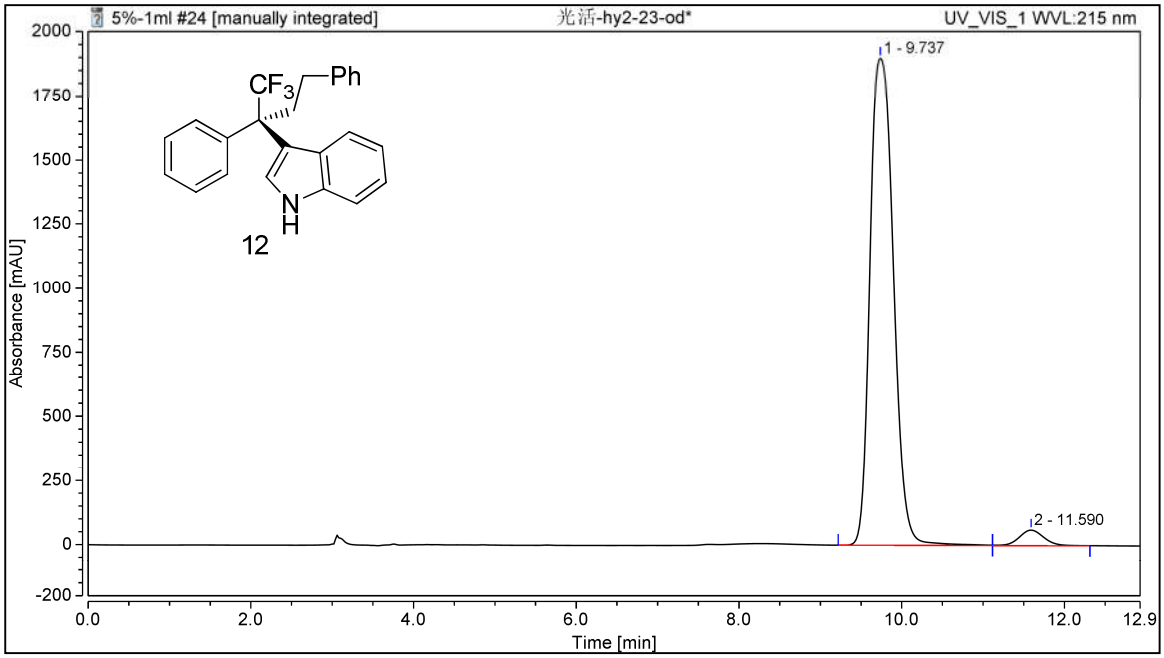
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		5.603	525.001	50.11	n.a.
2		8.480	522.746	49.89	n.a.
Total:			**1047.746**	**100.00**	



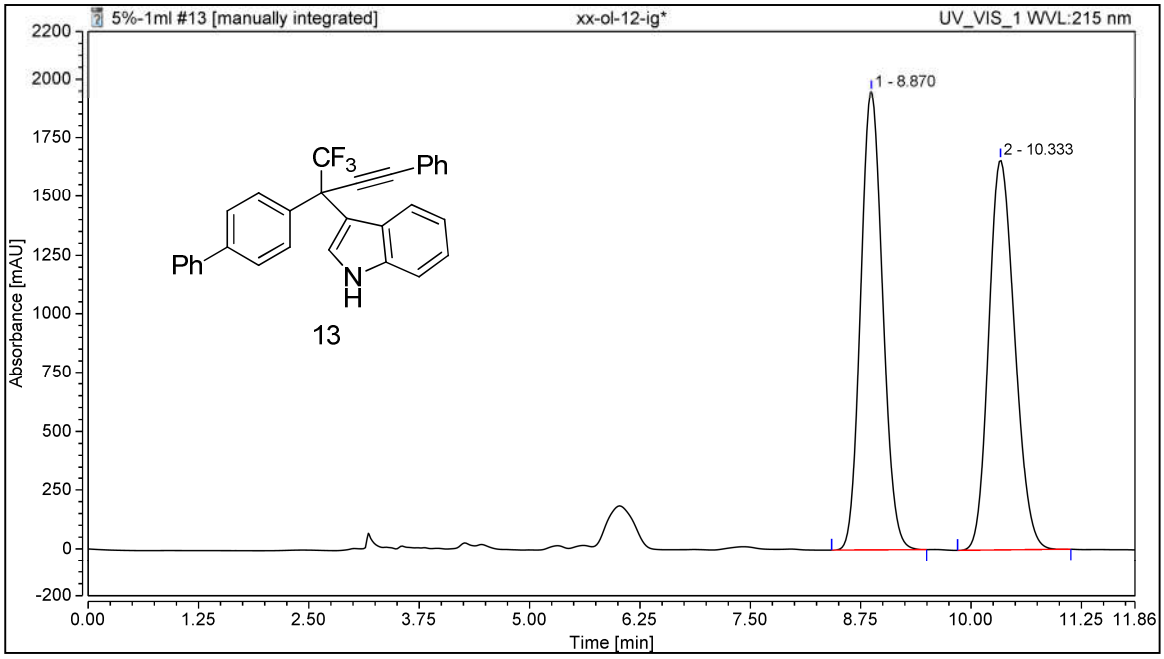
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		5.647	24.501	3.50	n.a.
2		8.487	676.027	96.50	n.a.
Total:			**700.528**	**100.00**	



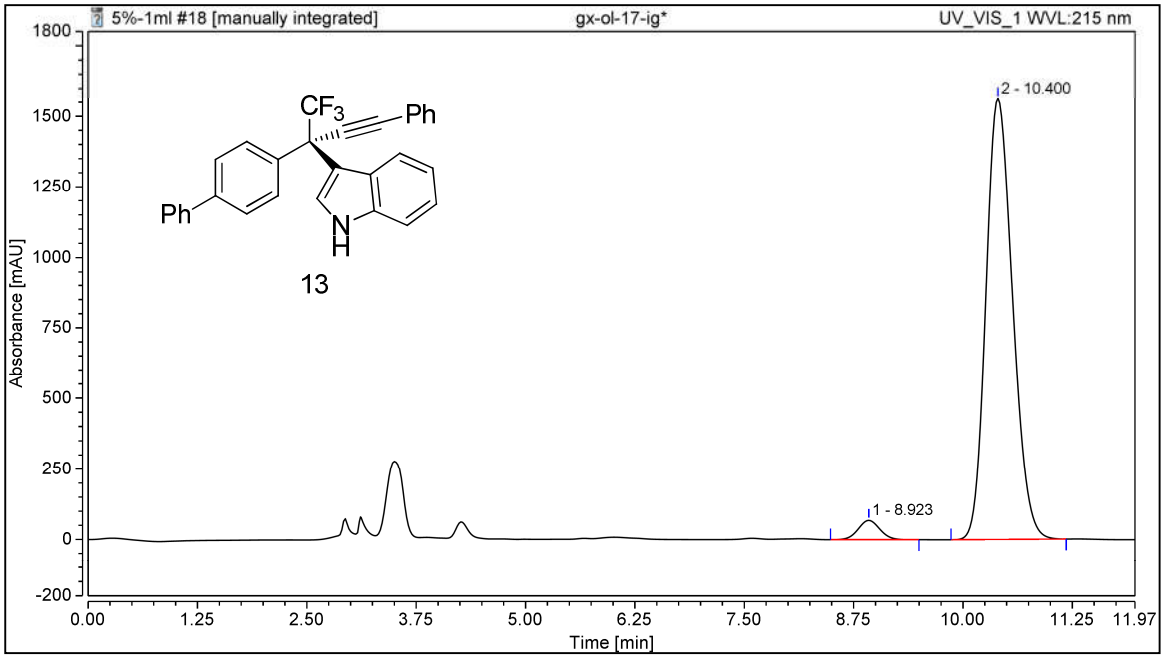
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		9.997	930.889	49.24	n.a.
2		11.873	959.503	50.76	n.a.
Total:			**1890.392**	**100.00**	



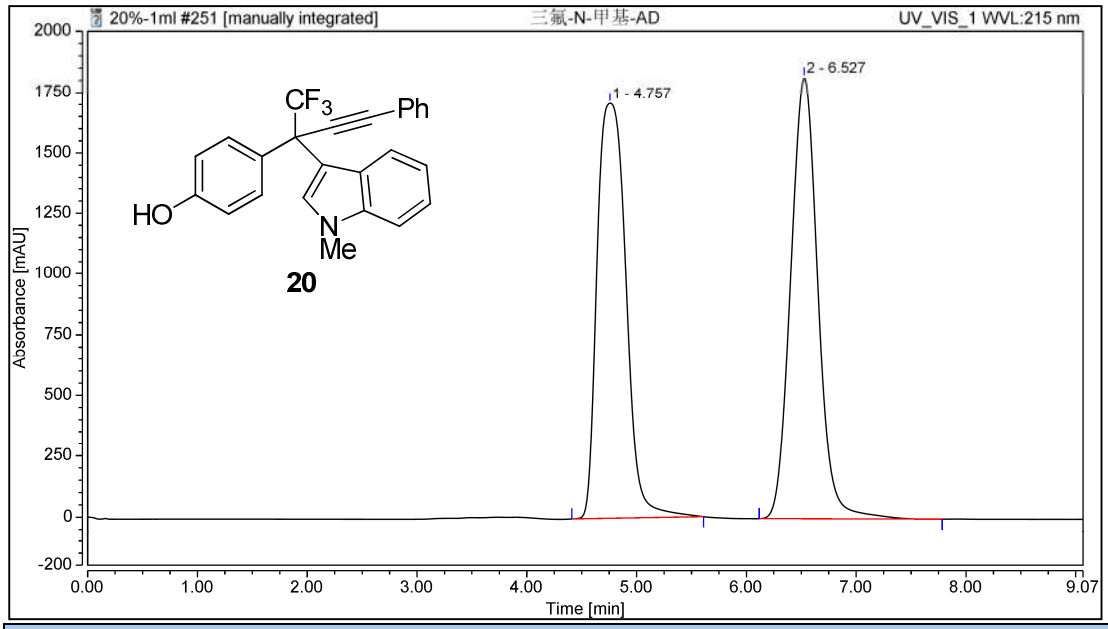
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		9.737	633.937	96.68	n.a.
2		11.590	21.793	3.32	n.a.
Total:			**655.730**	**100.00**	



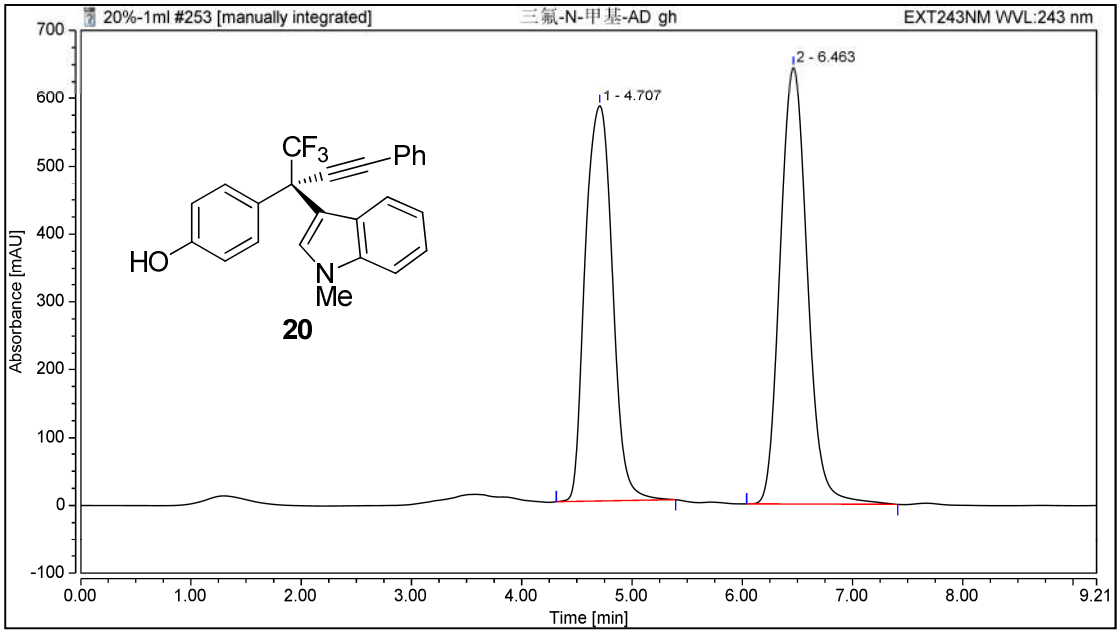
Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		8.870	563.779	49.94	n.a.
2		10.333	565.087	50.06	n.a.
Total:			**1128.867**	**100.00**	



Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		8.923	19.510	3.42	n.a.
2		10.400	551.122	96.58	n.a.
Total:			**570.632**	**100.00**	



Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		4.757	519.650	49.98	n.a.
2		6.527	520.012	50.02	n.a.
Total:			**1039.663**	**100.00**	



Integration Results					
No.	Peak Name	Retention Time min	Area mAU*min	Relative Area %	Amount n.a.
1		4.707	166.529	47.45	n.a.
2		6.463	184.445	52.55	n.a.
Total:			**350.974**	**100.00**	